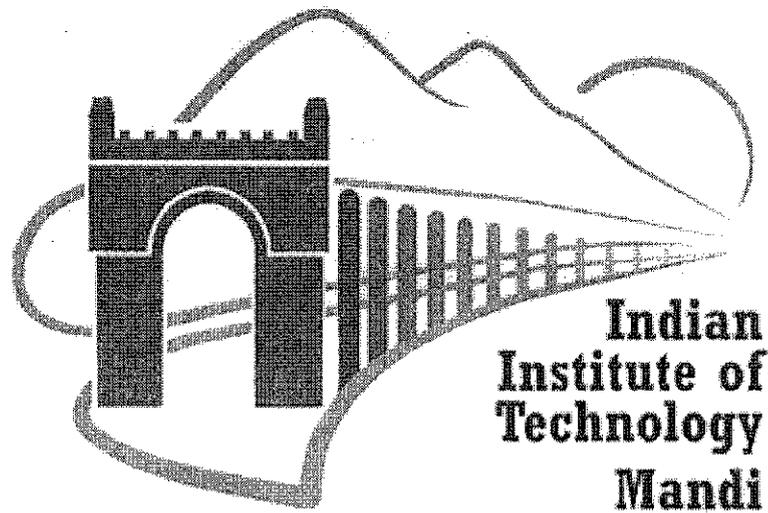


**INDIAN INSTITUTE OF TECHNOLOGY MANDI**  
**KAMAND, DISTT. MANDI – 175005 (HIMACHAL PRADESH)**



**MINUTES OF 29<sup>TH</sup> BOARD OF ACADEMICS MEETING**

VENUE : A-4 CONFERENCE ROOM, KAMAND  
DATE : 7<sup>TH</sup> MARCH, 2019 (THURSDAY)  
TIME : 04:00 P.M.

**Following members attended the meeting**

Sl.No	Responsibilities	Name
1	Dean Academics	Dr. Pradeep Parameswaran
2	Associate Dean (Research)	Dr. Rahul Vaish
3	Associate Dean (Courses)	Dr. Anil K Sao
4	Chairman Library Advisory Committee	Dr. Astrid Kiehn
5	Chairman Course Proposal Committee + Nominee (SCEE)	Dr. Kunal Ghosh
6	Course Coordinator (IC Courses)	Dr. Aniruddha Chakraborty
7	Course Coordinator (MA Dev. Studies) + Nominee (SHSS)	Dr. Shyamasree Dasgupta
8	Course Coordinator (B.Tech.-CSE)	Dr. Dileep A D
9	Course Coordinator (B.Tech.-EE)	Dr. Shubhajit Roy Chowdhury
10	Course Coordinator (B.Tech.-ME)	Dr. Arpan Gupta
11	Course Coordinator (B.Tech.-CE)	Dr. Deepak Swami
12	Course Coordinator (M.Tech.- (Energy Engg. (Materials)))	Dr. Atul Dhar
13	Course Coordinator (M.Tech.- (Mechanical Engg. (Energy Systems)))	
14	Course Coordinator (M.Tech.- (Communication and Signal Processing))	Dr. Renu M Rameshan
15	Course Coordinator (M.Tech.-Biotechnology)	Dr. Shyam K Masakapalli
16	Course Coordinator (M.Sc.-Applied Maths)	Dr. Nitu Kumari
17	Course Coordinator (M.Sc.-Physics) + (I-Ph.D. (Physics))	Dr. Ajay Soni
18	Nominee-1: School of Engineering	Dr. Rajesh Ghosh
19	Nominee-2: School of Engineering	Dr. Venkata Uday Kala
20	Nominee-2: School of Computing & Electrical Engineering	Dr. Aditya Nigam
21	Nominee-1: School of Basic Sciences	Dr. Syed Abbas
22	Nominee-2: School of Basic Sciences	Dr. Prosenjit Mondal
23	Nominee-1: School of Humanities & Social Sciences	Dr. Suman Sigroha
24	Academic Affairs Secretary	Mr. Abhishek
25	Assistant Registrar (Academics): Secretary	Mr. Suresh Rohilla



**Following members could not attend the meeting**

Sl.No.		Name	
1	Course Coordinator M.Sc. (Chemistry)	Dr. Chayan K Nandi	Member
2	Course Coordinator (M.Tech.-(VLSI))	Dr. Satinder Sharma	Member
3	Course Coordinator (M.Tech.-(Power Electronics and Drives))	Dr. Narsa Reddy Tummuru	Member
4	Research Affairs Secretary	Mr. Ashish Tiwari	Member
5	Industry Member – 1	Dr. Nadeem Akhtar	Member

**Special Invitee**

Sl.No.	Name	
1.	Dr. Tulika Srivastava	Asso. Prof., SBS
2.	Dr. Arnav Bhavsar	Asst. Prof. , SCEE
3.	Dr. Manoj Thakur	Asso. Prof., SBS
4.	Dr. Kalpesh Haria	Asst. Prof. , SBS
5.	Dr. Qaiser Jahan	Asst. Prof. , SBS
6.	Dr. Amit Prasad	Asst. Prof. , SBS

**PART-A**

**(Issues discussed by the Board of Academics when the Student Members were present)**

**29.1 Confirmation of the minutes of 28<sup>th</sup> meeting of Board of Academics:**

The minutes of the 28<sup>th</sup> Board of Academics meeting held on 29<sup>th</sup> January, 2019 were confirmed.

**29.2 To consider approval of courses presented by the Course Proposal Committee (CPC):**

The Chairperson, CPC presented six courses for consideration and approval of BoA. After due deliberations, the BoA recommended one course for consideration by the Senate for it's approval. The final course description after incorporating the suggested changes is placed at Annexure – A.

Sl.No.	Course No.	Course Name	Credits
1	IC 252	Data Science 2	3-0-2-4



The following five courses were deferred by the BoA with a suggestion to process the proposals again through CPC after obtaining comments from external experts:-

Sl.No.	Course No.	Course Name	Credits
1	MA 603	Advanced Partial Differential Equation	3-0-0-3
2	MA 521	Functional Analysis	3-1-0-4
3	MA 520	Industrial/Academic Internship	0-0-2-1
4	MA 705	Modelling Population Dynamics	3-0-0-3
5	MA 511	Real Analysis	3-1-0-4

**29.3 To consider the revised proposal of M.Sc. in Applied Mathematics Curriculum:**

Dr. Nitu Kumari, Course Co-ordinator M.Sc. Applied Mathematics briefed BoA on the revised curriculum for M.Sc. in Applied Mathematics. She mentioned that the revisions are being proposed as per the suggestions of SBS Review Committee. The board deliberated and suggested some minor changes. She was requested to modify the proposal accordingly. The modified and final proposal placed at **Annexure-B** is recommended for consideration by the Senate for its approval.

**29.4 To consider the revised proposal of M.Tech. (CSP) Curriculum:**

Dr. Renu Rameshan, Course Co-ordinator M.Tech. (CSP) briefed BoA on the revised curriculum for M.Tech. (CSP). She submitted that after running the program for two years and with the industry interactions (through the students who are doing project with industry) concluded that the present curriculum is heavily oriented towards theory. In order to meet the industry demand the curriculum is being revised by introducing more practical oriented courses and also by giving choice to the students to opt for an applied track or a theoretical track. This will also improve the job opportunities to the students. The board deliberated and suggested some changes and requested to modify the proposal accordingly. The modified and final proposal placed at **Annexure-C** is recommended to the Senate for its consideration and approval.

**29.5 To consider the proposal of semester exchange for M.Tech. (CSP) students:**

Board of Academics considered the proposal of semester exchange for M.Tech. (CSP) students. The board considered the possibility for semester exchange as proposed but with the foreign universities having MoU with IIT Mandi. The BoA decided to recommend the proposal for Senate approval with a comment that these guidelines may be applicable for all M.Tech students. The proposal is placed at **Annexure-D**.

**29.6 To consider proposal for B.Tech. in Data Science and Engineering.**

Dr. Manoj Thakur presented a proposal to the Board for “B.Tech. in Data Science and Engineering”. The Board deliberated on the proposal and suggested the overall programme structure should be in line with other existing B.Tech programmes and thus the segmenting of the offering of core courses like IC and HSS courses etc. should be maintained. The Board requested Dr. Manoj Thakur to modify the proposal accordingly and recommended the same to the Senate for its consideration and approval. Modified proposal for “B.Tech. in Data Science and Engineering” is placed as **Annexure – E**.

**29.7 To consider proposal for B.Tech.-M.Tech Integrated Dual Degree Programme in Bio-engineering.**

Dr. Shubhajit Roy Chowdhury briefed the Board on the proposal for “B.Tech.-M.Tech Integrated Dual Degree Programme in Bio-engineering”. The Board deliberated on the proposal in details and suggested the following:-

- (i) The sequence of the offering of the common courses like IC courses, HSS courses etc. should be similar to that of the existing B.Tech Programs.
- (ii) The option of modifying the proposal in line with the “B.Tech to Integrated M.Tech Conversion” rules and regulations approved by Senate may be explored.

The BoA recommended the proposal in principle for Senate’s consideration and approval. BoA also entrusted the Senate to take appropriate decisions on the ‘Branch Change policy’ and the ‘Exit option after 4 years with B.Tech’ from this program.

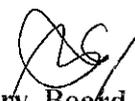
The Board requested Dr. Shubhajit Roy Chowdhury to discuss these points with the committee and revise the proposal appropriately. Modified proposal for B.Tech.-M.Tech Integrated Dual Degree Programme in Bio-engineering is placed as **Annexure – F**.

**29.8 Any other item with the permission of the Chair.**

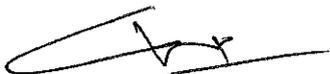
In addition to the circulated agenda points, with the permission of Chairman BoA, the Board of Academics deliberated on the proposal for B.Tech.in Engineering Physics which already had been considered by the Senate in it’s 19<sup>th</sup> Meeting with an observation to take comments from external experts. The BoA perused the obtained remarks and recommended the proposal for Senate approval. Modified proposal for B.Tech in Engineering Physics is placed as **Annexure – F**.



The meeting ended with a vote of thanks to the Chair.



Secretary, Board of Academics



Chairman, Board of Academics

**IIT Mandi**  
**Proposal for a New Course**

**Course Number:** IC 252

**Course Name:** Data Science 2

**Credits:** 3-0-2-4 (L-T-P-C)

**Prerequisites:** IC 110, IC 152.

**Intended for:** First year B.Tech

**Distribution:** Institute core for B. Tech

**Semester:** Even/Odd

**Preamble:** Uncertainty is a phenomenon which is observed in several areas – science, statistics, finance - and in daily life. Probability is the logical framework which enables one to quantify uncertainty and randomness. Though the area is quite counter-intuitive, following the rules laid out by the mathematical theory of probability helps one in avoiding mistakes while dealing with uncertainty. Probability theory part of the course provides the mathematical basis and in the statistics part one learns how to use probability to make sense of data, which is important in a world which is largely data driven currently.

**Objective:** After finishing this course the student should be able to formulate probability models and evaluate event probabilities, have a clear understanding of independence, application level understanding of conditional probability, Bayes theorem and random variables, do a statistical analysis of data using the WLLN, CLT; formulate and test hypothesis; and find relations between random variables by using regression. On a lighter note after finishing the course successfully the student should be able to accept and deal with uncertainty comfortably with an understanding of the common pitfalls as well as make reasonable predictions from data.

**Syllabus:**

1. Probability: Why probability and what is it? (give real life situations which demands use of probability). Counting, combinations, permutations, binomial and multinomial coefficients, Stirling's formula. Discrete probability spaces (with examples). Axiomatic definition of probability, inclusion-exclusion formula, independence, condition probability, Bayes' rule. (*Note: Cover the paradoxes and well known problems*).

(6 lectures)

Lab: counting, basic probability – simulation of simple experiments, birthday paradox, conditional probability.

2. Random variables: definition, distribution function and its properties, probability mass function (binomial, Bernoulli, Poisson, geometric), probability density function (uniform, exponential, Gaussian). Joint distributions, independence and conditioning of random variables. Function of random variables, change of variable formula.

(9 lectures)

Lab: Generating random variables following a given pdf/pmf. engineering application of functions of random variables.

3. Measures of central tendency, dispersion and association – expectation, median, variance, standard deviation, mean absolute deviation, covariance, correlation and entropy (definition and guidelines on how to choose a particular measure). Markov and Chebyshev inequalities. Notion of convergence in probability and distribution. Weak law of large numbers and central limit theorem (examples demonstrating the use of WLLN and CLT). Montecarlo methods (estimating value of  $e$ ,  $\pi$ , simulation of birthday paradox). Poisson limit for rare events.

(11 lectures)

Lab: Scatter plot (for independent, correlated, uncorrelated random variables), Montecarlo simulation, WLLN and CLT.

4. Statistics: Using probability to understand data (give real life examples). Frequentist approach - point and range estimates, confidence intervals, hypothesis testing p-values, significance level, power and t-test. Bayesian inference – maximum likelihood estimation. Regression.

(14 lectures)

Lab: Parameter estimation, hypothesis testing, regression.

5. Case study: Analyze a large data set (medicine/engineering/biological) using the methods covered in the course.

(2 lectures)

#### Textbooks:

1. Sheldon Ross, Introduction to Probability and Statistics for Engineers, 5/e (2014), Elsevier

#### Reference books:

1. Morris H. DeGroot and Mark J. Schervish, Probability and Statistics (4/e)(2012), Addison-Wesley.
2. Blitzstein and Hwang, Introduction to Probability (2015), CRC Press.
3. William Feller, An Introduction to Probability, (3/e) (2008), Volume 1, Wiley.
4. Freedman, Pisani, Purves, Statistics (4/e)(2014), W. W. Norton & Company.

#### Similarity Content Declaration with Existing Courses:

Introductory institute core meant for undergraduate engineering students.

**Justification for new course proposal if cumulative similarity content is > 30%: NA**

#### Approvals:



Other faculty interested in teaching this course:

Proposed by:

School: SCEE

Signature:

Date: 20 November 2018

Recommended/Not recommended, with comments

Chairperson, Course proposal committee (CPC)

Date:

Approved / Not Approved

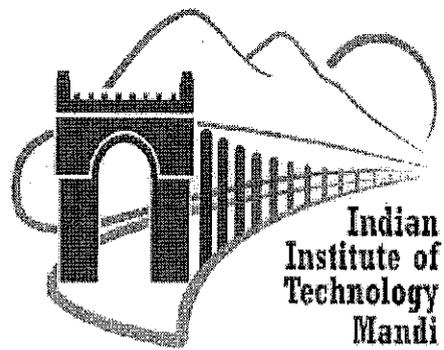
Chairperson, Senate

Date:





*M.Sc. in Applied Mathematics Program at IIT Mandi*



**School of Basic Sciences**

**Indian Institute of Technology Mandi**

**Preamble:** *M.Sc. in Applied Mathematics* programme at IIT Mandi is intended to give the students deep understanding of the principles of Mathematical sciences while expanding their knowledge in the allied areas through elective courses. The curriculum has been designed so as to prepare the students to take up a research career either in academia or in industries on completion of the program. The students will be equally equipped to take up professional career in Industries. The structure of the proposed programme has been designed drastically amended from the conventional M.Sc. (Mathematics) programs across the country by providing a balance among theory, application, and research components. The program is designed in such a way that students will have enough choices to learn their desired subjects by taking number of elective courses from and outside of the discipline. The curriculum focuses on an interdisciplinary approach wherein students learn theory and its applications (through fundamental core courses and engineering open elective courses) those are required for research in applied Mathematics and industry jobs:

- Broad based curriculum by the inclusion of a number of free and discipline electives, without compromising the core subjects.
- Theory and application oriented courses.
- Research oriented curriculum to increase thinking power' and 'Problem solving ability'.
- Adequate blend of theory and research.
- Learning of advanced Mathematical tools to solve engineering and real-life problems.
- Generates enough opportunities for industry jobs.

**Name of the Program:** M.Sc. in Applied Mathematics. (Provision for *specialization/major/minor* is not at present, but it may added in future)

**Duration:** 2 Years (4 semesters).

**Eligibility:** As per the institute's norm mentioned in the Ordinance & Regulations for M.Sc. programme.



**Semester-wise credit distribution:**

<b><u>Semester I</u></b>		<b><u>Semester II</u></b>	
Real Analysis	- 4 Credit	Functional Analysis	- 4 Credit
Linear Algebra	- 4 Credit	Partial Differential Equation	- 4 Credit
Ordinary Different Equation	- 4 Credit	Numerical Analysis	- 4 Credit
Computer Programming	- 3 Credit	Probability & Statistics	- 4 Credit
Computer Programming Lab	- 2 Credit	Technical Communication	- 1 Credit
Applied Mathematical Programming	- 4 Credit	Discipline Elective I	- 3 credits
<b>Total</b>	<b>- 21 Credit</b>	<b>Total</b>	<b>- 20 Credit</b>
<b><u>Semester III</u></b>		<b><u>Semester IV</u></b>	
Discipline Elective II	- 3 Credit	Elective – V	- 3 Credit
Elective – II	- 3 Credit	Elective – VI	- 3 Credit
Elective – III	- 3 Credit	Project (Part-2)	- 12 Credit
Elective – IV	- 3 Credit		
Project (Part-1)	- 9 Credit		
<b>Total</b>	<b>- 21 Credit</b>	<b>Total</b>	<b>- 18 Credit</b>

**Credit Structure:** A student, to be awarded M.Sc. degree, must need to earn 80 credits.

**Student strength:** The number of seats will be revised every year as decided by the administration.

**Open Electives:** Open electives from outside the discipline of program should be at least of 6 credits.

**Discipline Electives:** Discipline electives will be provided according to the requirement of the students and the availability of the faculties.

The following existing senate approved courses can be offered as discipline electives. More elective courses will be added time to time as required.

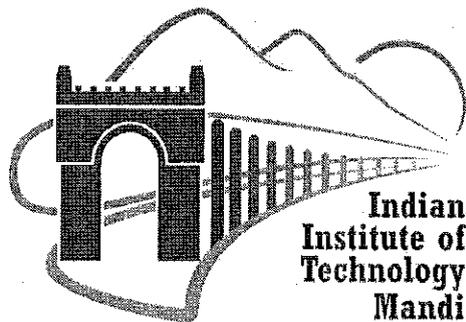
Course Numbers	Course Titles	Credits
MA-549(3)	Abstract Algebra	3
MA-550(3)	Statistical Data Analysis	3
MA-552(3)	Number Theory	3
MA-553(3)	Mathematical Foundations of Financial Engineering	3
MA-565(3)	Numerical Methods in Quantitative Finance	3
MA-608(3)	Computational Fluid Dynamics	3
MA-609(3)	Numerics of Partial Differential Equation	3
MA-651(3)	Optimization Techniques	3
MA-652(3)	Stability Theory of Differential Equations	3
MA-653(3)	Computational Financial Modelling	3
MA-654(3)	Financial Engineering	3
MA-656(3)	Stochastic Calculus for Financial Engineering	3
MA-665(3)	Semigroup of Bounded Linear Operators	3
MA-704(3)	Dynamical System	3
MA-705(3)	Modeling Population Dynamics	3
MA-709(3)	Numerical Linear Algebra	3
MA-780 (3)	Topics in Semigroup Theory	3
MA-765(4)	Fractional Differential Equations	4

**Project Evaluation:** A continuous evaluation process will be followed to evaluate the project/thesis work progress to award letter grades for the credits assigned to project/thesis component, as mentioned in the institute's Ordinance for M.Sc. programme.

## **Proposal for**

### **Master of Technology**

- 1. Master of Technology in Communication and Signal Processing**
- 2. Master of Technology in Communication and Signal Processing with specialization in Signal Processing**
- 3. Master of Technology in Communication and Signal Processing with specialization in Communication**
- 4. Master of Technology in Communication and Signal Processing with specialization in Machine Learning**



**School of Computing and Electrical Engineering,  
Indian Institute of Technology Mandi,  
Himachal Pradesh, India.**

## **1. Name of the Degree Program**

1. Master of Technology in Communication and Signal Processing.
2. Master of Technology in Communication and Signal Processing with specialization in Signal Processing.
3. Master of Technology in Communication and Signal Processing with specialization in Communication.
4. Master of Technology in Communication and Signal Processing with specialization in Machine Learning.

## **2. Abbreviation**

Master of Technology is abbreviated as M.Tech

## **3. Duration**

The duration of this program is two years. Each year consists of two semesters, summer and winter terms.

## **4. Credits to be earned**

The students have to earn minimum of 71 credits for the degree of Master of Technology in Communication and Signal Processing and Master of Technology in Communication and Signal Processing with specializations. Credit distribution details are in Annexure 1.

## **5. Eligibility**

- a) Candidates who have qualified for the award of Bachelor's degree in Engineering / Technology from a recognized University or Institute in Electrical/Electronics and Communication/Telecommunications Engineering (ECE), Telecommunications Engineering (T), Electrical & Electronics Engineering (EEE), Instrumentation (IN) with minimum 60% (CGPA 7.5), and who have qualified and have a valid score in Graduate Aptitude Test in Engineering (GATE) in ECE are eligible to apply for admission to the this program.
- b) For all B.Techs from IITs graduated with a CGPA of 8.0 or above, the requirement of GATE qualification is waived off.
- c) A student sponsored by a recognized R&D organization, academic institution, government organization or industry are eligible to apply for this program on a full-time basis. The Institute does not provide any assistantship to such students.
- d) A candidate with Associate Membership of Professional Bodies equivalent to B.Tech., as approved by the Senate and having valid GATE score in ECE shall also be eligible to apply for admission to this program with assistantship, subject to regulations approved by the Senate.

For more details on eligibility criteria please refer to ordinance and regulations for M.Tech./M.Sc. of IIT Mandi.

## **6. Categories of Admission**

Candidates will be admitted to the M.Tech. program of the Institute under one of the following categories:

1. Regular full-time students with Half-teaching Research Assistantship (HTRA) assistantship
2. Full time sponsored students by the Industries, established Institutes/R&D Organizations/National laboratories without HTRA assistantship.

## **7. Selection**

For admission to this M.Tech. program under regular category, the School shall adopt qualifying criteria based on GATE score, B.Tech percentage/CGPA and interview. GATE score will be used for shortlisting students for the interview. Sponsored category students with more than two years experience will be short listed for interview. Their selection is based on the interview performance and B.Tech percentage/CGPA.

## **8. Number of Seats**

The actual number admitted in each year and the reservation roster will be decided administratively.

## **9. Assistantship (Fellowship/Scholarship)**

The award of assistantship shall be in accordance with prevailing norms of the Institute.

## **10. Award of Degree**

Award of the M. Tech. degree shall be in accordance with the regulation of the Senate in relation to the requirements of the given program.

## **11. Academic Events**

The dates of academic events scheduled during the academic session shall be specified in the academic calendar.

## **12. Campus Stay**

Students admitted to these degree programs are required to stay in campus and to participate and complete all requirements of the program.

## **13. Exception**

Any exception to above clauses will require approval of the Senate or by the Chairman, Senate.

Other details are in accordance with ordinance and regulations for M.Tech/M.Sc of IIT Mandi.

**Annexure 1**  
**Course and credit details**

**General details**

1. There are 5 core courses. The remaining courses (excluding the open electives) are grouped into three baskets.
2. It is mandatory to take one course from each basket. Minimum credits required – 9.
3. Students who would like to go for a specialization should take 9 more credits (in addition to the mandatory credits in point 2) from which ever basket they want to specialize.
4. Those who don't want any specialization can take courses to satisfy 9 credits from across the baskets.
5. Project is of one year duration
6. Projects should be industry sponsored.
7. System design (winter project) – after first year.
8. Postgraduate project starts from the summer following first year and extends to third and fourth semesters.

**Minimum credit requirements**

	Credits
1. Discipline core (DC)	16
2. Specialization basket (SB)	18*
3. System design	2
4. Post graduate project	28
5. Open electives	6
6. Technical communication	1
<b>Total</b>	<b>71</b>

SB\* - Out of these 18 credits, 9 credits should be earned by taking one course each from the 3 baskets. The remaining 9 credits can be chosen from the same basket or from across baskets.

**I year, Semester 1**

Code	Subject	Credit	Remarks
EE 5XX*	Probability and Random Processes	3-0-0-3	DC
EE 522	Matrix Theory	3-0-0-3	DC
CS 5XX*	Advanced Programming Practicum	1-0-3-3	DC
	Specialization Basket	3-0-0-3	SB
	Specialization Basket	3/4	SB
	Technical Communication	1	
	<b>Total credits</b>	<b>16/17</b>	

\* The course proposals are ready, but CPC process and BoA approval is pending.



**I Year, Winter**

EE 532	System design	2
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**I year, Second Semester**

Code	Subject	Credit	Remarks
EE 530	Applied/Practical Optimization	2-0-2-3	DC
EE 529	Embedded Systems	3-0-2-4	DC
	Specialization basket	3	SB
	Specialization basket	3	SB
	Specialization basket	3	SB
	Outside disciplin elective*	3	OE
	Total credits	<b>19</b>	

**II Year, Third Semester**

Code	Subject	Credit	Remarks
	Specialization basket	3	SB
	Open elective*	3	OE
EE 626P	Project	10	
	Total credits	<b>16</b>	

**II Year, Fourth Semester**

Code	Subject	Credit	Remarks
EE 627P	Project	18	
	Total credits	<b>18</b>	

The list of courses follows:

**Discipline Core**

	Code	Course Name	L-T-P-C
1	EE5XX	Probability and Random Processes	3-0-0-3
2	EE 522	Matrix theory	3-0-0-3
3	EE 530	Applied Optimization	2-0-2-3
4	CS 5XX*	Advanced Programming Practicum	1-0-3-3
5	EE 529	Embedded Systems	3-0-2-4

\*To be approved by BoA

### Signal processing Basket

	Code	Course Name	L-T-P-C
1	EE 620	Advanced Digital Signal Processing	3-0-0-3
2	EE 62X	Modern Signal Processing	3-0-0-3
3	EE 608	Digital Image Processing	3-0-2-4
4	CS 609	Speech Processing	3-0-2-4

### Communication Basket

	Code	Course Name	L-T-P-C
1	EE 503	Advanced Communication Theory	3-0-0-3
2	EE518	Information Theory	3-0-0-3
3	EE 517	Wireless Communication	3-0-0-3
4	CS 549	Computer Networks Analysis	3-0-0-3
5	EE 530	Estimation and Detection Theory	3-0-0-3
6	EE 507	Transmission lines and Basic Microwave engineering	3-1-0-4
7	EE 621	Radiating Systems	3-1-0-4
8	CS 541P	IoT Systems and the Cloud	1-0-3-3

### Machine learning basket

	Code	Course Name	L-T-P-C
1	CS 669	Pattern Recognition	3-1-0-4
2	EE 511	Computer Vision	3-1-0-4
3	CS 671	Deep Learning and Applications	3-0-1-4
4	EE 530	Estimation and Detection Theory	3-0-0-3

### Outside discipline electives

Any graduate level course outside of the Communication and Signal Processing discipline from the School or from other Schools are acceptable as open electives.

Semester Exchange for M.Tech CSP students

1. Possibility of semester exchange with foreign universities (through Institute/ Government schemes) during the third semester.
2. Credit requirement for third semester is 16 credits – 10 for project, 6 for open and discipline electives.
3. A student going for semester exchange should register for project at IIT Mandi and the evaluation will be done through Video Conference.
4. The remaining 6 credit requirement can be met either by taking courses at IIT Mandi in the final semester or by registering for courses in the host university. For the latter we need to come up credit and grade transfer rules in cases where there is no MoU already signed.





List of Core courses for Data Science and Engineering Program

(Total Credits for discipline core = 30)

S. No.	Course Title	Lecture	Tutorial	Practical	Total Credit	Semester
1	Data handling and visualization	2	0	2	3	III
2	Mathematical Foundations of Data Science I	3	0	0	3	III
3	Introduction to Data structures and Algorithms	2	0	2	3	IV
4	Statistical Foundations of Data Science	3	0	0	3	IV
5	Mathematical Foundations of Data Science II	3	0	0	3	V
6	Matrix Computations for Data Science	2	0	2	3	V
7	Information Security and Privacy	3	0	0	3	V
8	Computing for Data Science	2	0	2	3	VI
9	Introduction to Statistical Learning	3	0	2	3	VI
10	Optimization for Data Science	3	0	0	3	VI

## Semester wise distribution of all courses

(Minimum credit requirements for B.Tech. degree 160 credits)

Abbreviations	
IC	Institute Core Subject (Compulsory to all branches of B.Tech.)
DC	Discipline Core Subject (branch specific compulsory courses)
DE	Discipline Elective Subject (branch specific elective courses)
OE	Open Elective (elective open to all branches of B.Tech.)
MTP (total 8 credits)	Major Technical Project (Optional, students may opt for courses instead )

B.Tech (Data Science and Engineering) - 1st Sem.						
S. No.	Core/ Elective	Course Name	Lecture	Tutorial	Practical	Credit
1	IC	Engineering Mathematics	2	1	0	3
2	IC	Data Science I + Lab	3	0	2	5
3	IC	Electrical Systems Around Us + Lab	3	0	2	5
4	IC	Graphics for design	3	0	1	4
5	IC	D& IP – Understanding Products through Reverse Engineering (Lab)	0	0	2	2
6	IC	HSS Course: Creative Understanding (5WIP)	1	0	0	1
7	HSS	English 1	3	0	0	3
Summary		Total No of Theory Courses	5	Total Credit		21
		Total No of Labs	4	Completed Credits		21
				Remaining Credits		139

B.Tech (Data Science and Engineering) - 2nd Sem.						
S.No.	Core/ Elective	Course Name	Lecture	Tutorial	Practical	Credit
1	IC	Linear Algebra	3	0	0	3
2	IC	Data Science II + Lab	3	0	2	4
3	IC	Applied Electronics + Lab	3	0	2	5
4	IC	Engineering Thermodynamics	3	0	1	4
5	IC	Product Realization Technology	2	0	0	2
6	IC	Product Realization Technology Lab	0	0	2	2
7	HSS	Language Basket Course	3	0	0	3
Summary		Total No of Theory Courses	6	Total Credit		23
		Total No of Labs	4	Completed Credits		44
				Remaining Credits		116

B.Tech (Data Science and Engineering) – 3rd Sem.						
S.No.	Core/ Elective	Course Name	Lecture	Tutorial	Practical	Credit
1	IC	Foundations of Electrodynamics + Lab	3	0	2	5
2	DC	Data handling and visualization	2	0	2	3
3	DC	Mathematical Foundations of Data Science I	3	0	0	3
4	IC	Data Science III + Lab	2	0	2	3
5	IC	Signals and Systems	3	0	0	3
6	IC	HSS Course	3	0	0	3
Summary		Total No of Theory Courses	6	Total Credit		20
		Total No of Labs	3	Completed Credits		64
				Remaining Credits		96

B.Tech (Data Science and Engineering) – 4th Sem.						
S.No.	Core/ Elective	Course Name	Lecture	Tutorial	Practical	Credit
1	IC	Materials Science for Engineers	3	0	0	3
2	IC	Continuum Mechanics	3	0	0	3
3	IC	Design Practicum	2	0	2	4
4	IC	Mechanics of Particles and Waves	3	0	0	3
5	DC	Introduction to Data structures and Algorithms	2	0	2	3
6	DC	Statistical Foundations of Data Science	3	0	0	3
Summary		Total No of Theory Courses	6	Total Credit		19
		Total No of Labs	2	Completed Credits		83
				Remaining Credits		77

B.Tech (Data Science and Engineering) – 5th Sem.						
S.No.	Core/ Elective	Course Name	Lecture	Tutorial	Practical	Credit
1	IC	Mechanics of Rigid Bodies	3	0	0	3
2	IC	Understanding Biotechnology & Its Applications/ Environmental Science & Engineering	3	0	0	3
3	IC	Applied Chemistry for Engineers + Lab	3	0	2	5
4	DC	Matrix Computations for Data Science	2	0	2	3
5	DC	Mathematical Foundations of Data Science II	3	0	0	3
6	DC	Information Security	3	0	0	3
Summary		Total No of Theory Courses	6	Total Credit		20
		Total No of Labs	2	Completed Credits		103
				Remaining Credits		57

B.Tech (Data Science and Engineering) - 6th Sem.						
S. No.	Core/ Elective	Course Name	Lecture	Tutorial	Practical	Credit
1	DC	Introduction to Statistical Learning	3	0	2	3
2	DC	Computing for Data Science	3	0	3	3
3	DC	Optimization for Data Science	3	0	0	3
4	DE-1	Discipline elective				3 / 4
5	DE-2	Discipline elective				3 / 4
6	OE-1	Open Elective				3 / 4
7	OE-2	Open Elective				3 / 4
Summary		Total No of Theory Courses	5	Total Credit		20-21
		Total No of Labs	2	Completed Credits		124-125
				Remaining Credits		35-36

B.Tech (Data Science and Engineering) - 5th Sem.						
S.No.	Core/ Elective	Course Name	Lecture	Tutorial	Practical	Credit
1	DE-3	Discipline elective				3 / 4
2	DE-4	Discipline elective				3 / 4
3	OE-4	Open Elective				3 / 4
4	OE-5	Open Elective				3 / 4
5	OE-6	Open Elective				3 / 4
6	MTP	MTP-I	0	0	0	3
Summary		Total No of Theory Courses		Total Credit		18-22
		Total No of Labs		Completed Credits		142-147
				Remaining Credits		13-18

B.Tech (Data Science and Engineering) - 5th Sem.						
S.No.	Core/ Elective	Course Name	Lecture	Tutorial	Practical	Credit
1	OE-7	Open Elective	3	0	0	3 / 4
2	OE-8	Open Elective	3	0	0	3 / 4
3	OE-9*	Open Elective	3	0	0	3 / 4
4	OE-10*	Open Elective	3	0	0	3 / 4
5	MTP	MTP-II	0	0	0	5
Summary		Total No of Theory Courses		Total Credit		158 + 2 (internship)
		Total No of Labs		Completed Credits		All

\* May not be required if candidate has completed sufficient credits in the earlier semesters.

Tentative list of elective courses

Sr. No.	Course title	Credit	Suggestive Baskets
1	Pattern Recognition	4	Machine Learning
2	Deep Learning	4	
3	Estimation and Detection Theory	3	
4	Kernel Methods for Pattern Analysis	4	
5	Digital Image Processing	4	
6	Computer Vision	4	
7	Biomedical Image and Signal Proc.	4	
1	IoT systems and the Cloud	3	Networks and Distributed Computing
2	Computer Networks	3	
3	High Performance Computing	2	
1	Algorithm Design and Algorithms	4	Theoretical Computer Science
2	Formal Concept Analysis: Theory and Practice	3	
3	Formal Languages and Automata Theory	3	
4	Semantic Analysis	4	
1	Linear Algebra	4	Applied Mathematics
2	Numerical Analysis	2	
3	Ordinary Differential Equations	3	
4	Introduction to Partial Differential Equations for Engineers	4	
1	Time Series	3	Statistics and Optimization
2	Optimization for Machine Learning	3	
3	Numerical Methods in Finance	3	
4	Computational Financial Modelling	3	
1	Cognitive Modelling	3	Neuroscience Basket
2	Computational Neuroscience	3	
3	Brain Inspired Computing	3	
4	Computational and Cognitive models of perception: Vision, Sound	3	

IIT Mandi  
Proposal for a New Course

Course Number : DS201  
Course Name : Data handling and visualization  
Credits : 2-0-2-3 (L-T-P-C)  
Prerequisites : None  
Intended for : UG  
Distribution : Discipline core for B. Tech. Data Science and Engineering, Discipline  
elective for B. Tech. Computer Science and Engineering, Electrical  
Engineering, Free elective for other B. Tech. disciplines

Semester : Even/Odd

Preamble: This course will provide undergraduate students with an understanding of the data collection, data representation and data visualization. Furthermore, this course will provide a general framework that allows students to identify errors associated with different data sources. Students will learn some metrics to quantify each potential error, and thus they will be able to describe the quality of a data source. The course will introduce different large-scale data collection efforts undertaken by industry and government agencies, and review the learned concepts through case-studies and examples. This course is suitable for students who are looking for a general framework to use data sources.

Objective: With the help of various examples students will learn how to identify which data sources likely matches research questions, how to turn research questions into measurable pieces, and how to think about an analysis plan.

On completion of this course, the student should be able to

- describe what makes a good or bad visualization
- demonstrate familiarity with various data sources
- Identify the functions that are best for particular problems
- Understand best practices for creating basic charts
- Learn data analysis tools and software

Course modules with Quantitative lecture hours:

1. Data sources and collection: (6 lectures)  
This module walks you through the process of data collection. Starting with a review of existing structured and unstructured data sources, we cover data collection techniques using sensors, surveys, and different instruments. This includes data collection and storing for different domains such as IoT, Audio and Video, Web and Social Networks etc.

2. Data Pre-processing: (7 lectures)  
Highlight the importance of data correction and discuss some basic features that can affect your data analysis when dealing with sample data. Issues of data access and resources for access are introduced in this module. Descriptive data summarization, data cleaning, normalization, data integration and transformation, data reduction.
3. Data representation: (9 lectures)  
Importance of data representations, Extracting salient features from data, Examples include MFCC from audio signals, histogram representation for text, feature representations for images, encoded representations, Spatial data representation: cartography, GIS paper maps to ArcGIS ArcMap symbolizing, Time-series data representations and curve fitting.
4. Basic charting and data visualization: (6 lectures)  
Basic charting, examples with real world weather data, extract and manipulate the data to display the maximum information, various types of graphs like pie chart, bar graphs, 3-D plots using Matlab and R. Procedure of composite charts by overlaying a scatter plot of record breaking data for a given year, Visualization of high dimensional data e.g. TSNE plot, histogram etc. Also, dynamic data representations and visualization of data using D3.js

#### Lab Exercises:

- Lab to be conducted on a 2-hour slot. It will be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class. The topics taught in the theory course should be appropriately be sequenced for synchronization with the laboratory.

#### Textbooks:

1. Yau, Nathan. *Visualize this: the Flowing Data guide to design, visualization, and statistics*. John Wiley & Sons, 2011.
2. Tufte, Edward R. *The visual display of quantitative information*. Vol. 2. Cheshire, CT: Graphics press, 2001.

#### Reference books:

1. Janert, Philipp K. *Data analysis with open source tools: a hands-on guide for programmers and data scientists*. O'Reilly Media, Inc., 2010.
2. Zhu, Xuan. *GIS for environmental applications: a practical approach*. Routledge, 2016.

IIT Mandi  
Proposal for a New Course

Course Number : DS203  
Course Name : Mathematical Foundations of Data Science I  
Credits : 3-0-0-3  
Prerequisites : IC152-Data Science I  
Intended for : UG  
Distribution : Discipline core for B. Tech. Data Science and Engineering, Not allowed  
to B.Tech. CSE, Free elective for other B. Tech. disciplines.  
Semester : Even/Odd.

Objective: During the last two decades, there has been a major paradigm shift in processing, communication, and storage of information from predominantly analog domain to digital domain for the reasons such as ease of implementation, better efficiency, greater robustness against noise, and enhanced performance and security. This shift has not only resulted in generation of ever increasing volumes of digital data but also an acute need to efficiently process, store, and communicate it. To address this need the focus of DSE curriculum must shift from introducing the traditional elementary discrete structures to represent and process the data to more abstract structures provided by fields such as graph theory. This will enable the students to better understand and appreciate the current developments at the frontiers of DS, both in theory and application, and prepare them to contribute to further advancement of such frontiers.

On completion of this course, students should be able to demonstrate their understanding of and apply methods of discrete mathematics in DS to subsequent courses in algorithm design and analysis, automata theory and computability, knowledge representation, information systems, information security. In particular, students should be able to

- use logical notation to define fundamental mathematical concepts such as sets, relations, functions and various algebraic structures, reason mathematically using such structures, and evaluate arguments that use such structures.

- model and analyse a computation process and construct elementary proofs based on such structures

Course modules with Quantitative lecture hours:

1. Fundamental structures:

Functions

(4 lectures)

Surjections, injections, inverses, composition.



- Relations (2 lectures)  
 Reflexivity, symmetry, transitivity, equivalence relations.
- Sets (5 lectures)  
 Venn diagrams, complements, Cartesian products, power sets, finite and infinite sets, introduction to lattices.
- Abstract orders: (4 lectures)  
 Quasi-order, partial order, well-order, (Advanced, optional topics: Zorn's lemma, Koenig's theorem.)
2. Combinatorics: (6 lectures)  
 Counting arguments/techniques; pigeonhole principle; cardinality and countability, the inclusion-exclusion principle, recurrence relations, generating functions.
3. Basics of graph theory: (3 lectures)  
 Graph as a discrete structure, graph coloring and connectivity, traversal problems, and spanning trees.
4. Introduction to graph mining: (3 lectures)  
 Large-scale connected components, similarity and centrality rankings, clustering.
5. Logic: (3 lectures)  
 Propositional and predicate logic: syntax, semantics, soundness, completeness, unification, inferencing, resolution principle, proof system.
6. Proof techniques (4 lectures)  
 Negation, contradiction, contraposition, mathematical induction) and the structure of formal proofs; efficiency of proof-systems.
7. Semantics: (3 lectures)  
 Introduction to operational semantics, structural operational semantics, Hoare logic.
8. State machines: (5 lectures)  
 Introduction, minimization, grammars, languages.

Textbook Book:

1. Lehman, E., Leighton, F. T., and Meyer A. R., *Mathematics for Computer Science*, 2013.

Reference Books:

1. Graham, R. L., Knuth, D. E., and Patashnik O., *Concrete Mathematics*, Pearson, 1994.
2. Aho, Alfred V., and Jeffrey D. Ullman. *Foundations of computer science*. Computer Science Press, Inc., 1992.
3. Tucker, A., *Applied Combinatorics*, Wiley, 2012.



4. Liu, A. and Mohapatra, D. P., *Elements of Discrete Mathematics*, Tata-McGraw Hill, 2008.
5. Koshy T., *Discrete Mathematics with Applications*, Academic Press, 2003.
6. Hein J., *Discrete Structures, Logic, and Computability*, Jones and Barlett, 2009.



IIT Mandi  
Proposal for New Course

**Course Number** : DS202  
**Course Name** : Introduction to Data Structures and Algorithms  
**Credits** : 2-0-2-3 (L-T-P-C)  
**Prerequisites** : None  
**Intended for** : UG  
**Distribution** : Core for B.Tech Data Science and Engineering, Not allowed to B.Tech. CSE  
Discipline elective for B.Tech in EE, Free elective for other B.Tech  
disciplines.  
**Semester** : Even/Odd

**Preamble:**

Data science uses the concepts from statistics and machine learning principles to write code such that one can effectively explore the problem at hand. This necessitates at least a basic understanding of data structures, algorithms, and time-space complexity so that one can program more efficiently and understand the tools used. With larger datasets, this becomes particularly important. The way that code is written influences the speed at which data is analysed and conclusions can be reached accordingly. The objective of the course is to expose students to relevant data structures and algorithms that relate to time complexity. At the end students will learn how to write efficient codes using suitable data structures and can design algorithms for practical data science related problems.

**Course Modules with Quantitative lecture hours:**

**Complexity Analysis:** (2 hours)

Time and Space complexity of algorithms, asymptotic analysis, average and worst case analysis, asymptotic notation, importance of efficient algorithms, program performance measurement, data structures and algorithms.

**Stacks, Queues and Lists:** (6 hours)

Abstract data types, sequential and linked implementations of stacks, queues and lists, comparison of insertion, deletion and search operations for sequential and linked lists, list and chain classes, doubly linked lists, circular lists, applications of lists in bin sort, radix sort, sparse tables.



**Hashing: (3 hours)**

Hashing as a search structure, hash table, collision resolution, universal hashing, linear open addressing, chains, hash tables in data-compression, LZW algorithm.

**Trees and Search Trees: (6 hours)**

Abstract data type, sequential and linked implementations, tree traversal methods and algorithms, Binary trees and their properties, Binary search trees, search efficiency, insertion and deletion operations, importance of balancing, AVL trees, searching, insertion and deletions in AVL trees, Tries, 2-3 tree, B-tree.

**Heaps: (3 hours)**

Heaps as priority queues, heap implementation, insertion and deletion operations, binary heaps, binomial and Fibonacci heaps, heapsort, heaps in Huffman coding.

**Graphs: (3 hours)**

Definition, terminology, directed and undirected graphs, properties, implementation - adjacency matrix and linked adjacency chains, connectivity in graphs, graph traversal - breadth first and depth first, spanning trees.

**Basic Algorithmic Techniques: (5 hours)**

Greedy algorithms, divide & conquer, dynamic programming. Search techniques - backtracking, Sorting algorithms with analysis, integer sorting, selection sort. Graph algorithms: DFS and BFS with applications, MST and shortest paths.

**Lab Exercises:**

- Lab to be conducted on a 2-hour slot. It will be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class. The topics taught in the theory course should be appropriately be sequenced for synchronization with the laboratory.

**Text book:**

1. Cormen, T. H., Leiserson, C. E., Rivest, R. L., and Stein C., *Introduction to Algorithms*, MIT Press, 2009.

**Reference Books:**

1. Sahni, S., *Data Structures, Algorithms, and Applications in C++*, Silicon Press, 2005.
2. Tenenbaum, A. M., Langsam Y., and Augenstein, M. J., *Data Structures Using C and C++*, Prentice Hall, 1995.

IIT Mandi  
Proposal for New Course

Course Number : DS303  
Course Name : Statistical Foundations of Data Science  
Credits : 3-0-0-3 (L-T-P-C)  
Prerequisites : IC110-Engineering Mathematics, IC252-Data Science 2  
Intended for : UG  
Distribution : Discipline core for B. Tech. Data Science and Engineering, Discipline  
elective for B. Tech. Computer Science and Engineering, Electrical  
Engineering, Free elective for other B. Tech. disciplines  
Semester : Even/Odd

In the context of data science, probability theory is the one of most important instrument for predictive modelling. It assists in the study of data and helps in making inferential decisions about it. Most of the commercial and open source software/packages available currently for the purpose of data analysis and prediction rely upon fundamental concepts of probability theory and statistics. A practitioner typically uses these concepts as a black box, but a data scientist capable of analyzing and designing new algorithms must have a clear understanding of the underlying notions. This helps in choosing/designing better tools for problem solving and analyzing the data. This course is intended to impart a strong background in probability theory to the students so that they are in a position to grasp notions involving probability in advanced topics such as statistical analysis, machine learning etc.

On completion of this course, students should be able to exhibit their understanding of various concepts of probability and statistics that are required in DSE for subsequent courses such as Statistical Learning and Pattern Recognition.

In particular, students should be able to

- understand the notion of random variables, their distribution properties and certain key results related to convergence and limit theorems.
- acquire adequate knowledge of various random processes and their properties.
- have a thorough understanding of various sampling techniques of practical importance and graphical models for machine learning and data science

Course modules with Quantitative lecture hours:

Sample space, Sigma field, axiomatic definition of probability, conditional probability and independence, Bayes Rule.

(2 lectures)

Review: Random variables – discrete and continuous, probability mass function, probability density function, some standard (important) pdfs, independence, expectation, variance,



conditional distribution, conditional expectation, covariance and correlation, Functions of random variables.

(7 lectures)

Probability generating function, moment generating function and characteristic functions – properties and applications.

(3 lectures)

Convergence of random variables – basic results, inequalities (Markov and Chebyshev), law of large numbers (weak and strong), central limit theorem.

(5 lectures)

Random vectors and covariance and correlation matrix, Random processes – stationarity, WSS, Autocorrelation, cross correlation, power spectral density, Ergodicity. Wiener processes, Markov processes, Poisson Process.

(8 lectures)

Sampling methods: Inverse transforms sampling, Rejection sampling, adaptive rejection sampling, importance sampling, Markov chains and MCMC

(8 lectures)

Graphical models: ML and MAP estimation, directed and undirected models, Bayesian networks, CRF, Learning and Inference method (ML, MAP, Sampling)

(9 lectures)

Textbook:

1. Grimmett, Geoffrey, and David Stirzaker. *Probability and random processes*. Oxford university press, 2001.
2. Bishop, Christopher M. *Pattern recognition and machine learning*. Springer, 2006.

Reference:

1. Ross, Sheldon. *A first course in probability*. Pearson, 2014.
2. Stark, Henry, and John William Woods. *Probability, statistics, and random processes for engineers*. Pearson, 2012.
3. Papoulis, Athanasios, and S. Unnikrishna Pillai. *Probability, random variables, and stochastic processes*. Tata McGraw-Hill Education, 2002.

IIT Mandi

Proposal for a New Course

Course Number : DS301  
Course Name : Mathematical Foundation of Data Science II  
Credits : 3-0-0-3  
Prerequisites : IC110-Engineering Mathematics, IC111-Linear Algebra  
Students intended for : UG  
Elective or core : Discipline core for B. Tech. Data Science and Engineering,  
Discipline elective for B. Tech. Computer Science and  
Engineering, Electrical Engineering, Free elective for other  
B. Tech. disciplines  
Semester : Odd/Even

**Preamble:** A large amount of work done in the area of data science and engineering span through range of very simple to mathematically elegant methods. A number of topics in mathematical analysis are of key interests to data science researchers. The mathematical analysis components offered in a typical mathematics program are often scattered in many specialised and dense courses. On the other hand mathematics courses offered in a typical computer science curriculum generally do not cover these important concepts that are very crucial for understanding of the core of many areas of machine learning. This introductory course aims to provide a graspable introduction to mathematical analysis required for data science and engineering practitioner.

On completion of this course, students should be able to demonstrate their understanding of and apply various concepts of mathematical analysis in DSE and serves as the input to many concepts in other courses on numerical linear algebra, optimization, and machine learning.

In particular, students should be able to

- acquire the adequate depth in relevant topics in mathematical analysis that adjoins to the knowledge of a data science practitioner.
- understand concepts related to notion of convergence in norm which is important ingredient in many of the techniques such as regression, classification and clustering requiring approximation different kind of functions.
- understand concepts of projection, orthogonality and their properties that are essential ideas for many machine learning techniques.

**Course modules with Quantitative lecture hours:**

**Module 1:** Definition of metric spaces, Examples, Open sets, Closed sets, Dense sets, Compact sets, Connectedness, Closure and interior of the sets, Metric subspace.

(10 lectures)



Module 2: Cauchy sequences, Convergent sequences, Complete metric space, , Continuous functions, Continuity of composite functions, Continuity and inverse image of open and closed sets.

(10 lectures)

Module 3: Normed linear spaces, Linear subspaces of normed linear spaces, Banach spaces, Riesz lemma, Continuity of linear maps, Bounded linear maps, Norm equivalence.

(10 lectures)

Module 4: Hilbert spaces, Cauchy -Schwarz inequality, Parallelogram law, Orthogonality, Pythagorean Theorem, Orthogonal projection, orthogonal complement and projection theorem, Orthonormal sets, Orthonormal basis, Gram-Schmidt process, Examples of orthonormal basis.

(12 lectures)

Text Books:

1. Apostol, T., Mathematical Analysis, 2nd ed., Narosa Publishers, 2002.
2. Limaye, B. V., Functional Analysis, 2nd ed., New age international Publishers, 2009.
3. Dan Simovici Mathematical Analysis for Machine Learning and Data Mining, World Scientific, 2018
4. Rudin, W., Principles of Mathematical Analysis, 3<sup>rd</sup> ed., McGraw-Hill, 2013.

Reference Books:

1. Stein, E. M. and Shakarchi, M., Real Analysis, Princeton Lectures.
2. Tao, T, Analysis I and II, Trim, Hindustan book agency.
3. Kreyszig, E., Introductory Functional Analysis with Applications, Reprint 2017
4. Naylor, A. C. and Sell, G. R., Linear Operator Theory in Engineering and Science.

IIT Mandi  
Proposal for a New Course

Course Number : DS402  
Course Name : Matrix Computations for Data Science  
Credits : 2-0-2-3  
Prerequisites : IC110-Engineering Mathematics, IC111-Linear Algebra  
Intended for : UG  
Distribution : Discipline core for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines  
Semester : odd/even

**Preamble:**

Many of the machine learning algorithms when applied to some practical problems often requires dealing with massive systems of linear equations or matrices. Due to increasing complexity in the real world scenarios and recent advances in the area of data science, understanding of numerical linear algebra and large scale matrix computations has become essential for data science practitioners.

**Objective and Learning Outcomes:**

After doing courses on engineering mathematics and linear algebra, students get conversant with various concepts related to multivariable calculus, vector spaces, linear transformations and basic matrix properties. To further enhance their expertise to cater the requirements to deal with large scale applications, this course introduces matrix factorization methods and their implementations. Also, direct and iterative methods for solving system of linear equations and eigenvalue problems of large dimensions are discussed.

This course tries to answer the fundamental question of choice of suitable matrix computation method with objective of having adequate speed and suitable accuracy in the computations. Hands-on experience with all the methods covered is the most crucial part of this course. All the topics discussed in this course would be accompanied with parallel practical session to reinforce the learning outcome of the course.

On completion of the module, students will be able to

- do some key matrix factorizations with the help of elementary transformations,
- identify suitable technique to solve linear systems of equations, least squares problems, and the eigenvalue problem,
- equate the efficacy and stability of different algorithms applied to solve linear systems, least squares problems, and the eigenvalue problem,
- understand and develop suitable matrix structures to deal with cases such as sparsity, banded structure, and symmetric positive definiteness,



## Course Modules with Quantitative Hours:

Basics : Errors in numerical computations. Review matrices and transformations, Matrix and Vector Norms.

(2 lectures)

Matrix factorizations : Cholesky factorization, QR factorization, Householder reflectors and Givens rotations. LU factorization and Gaussian elimination. Numerical stability Pivoting strategies and solution of triangular and full systems by factorization.

(5 lectures)

Eigenvalue problem: Basic theory, Power method, bisection method, QR algorithm. Similarity reduction.

(4 lectures)

Linear least squares problem : Singular value decomposition, Moore-Penrose Pseudoinverse. Perturbation theory. Least square and normal equations. SVD and rank deficiency, Principal Component Analysis, Linear Discriminant Analysis.

(6 lectures)

Iterative methods for linear systems : Iterative methods for linear systems Iterative methods: Jacobi, Gauss-Seidel and SOR iterations. Kronecker product. Krylov subspace methods, conjugate gradient method, preconditioning.

(5 lectures)

Sparse and banded linear systems :

Storage schemes for banded and sparse matrices, Sparse matrices and sparse solutions: approximate inverses, eigenvalues, incomplete factorization. Matrix regularization: matrix completion.

(6 lectures)

Lab Exercises: Lab would be conducted on a 2-hour weekly slot. Lab sessions would be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class.

## Textbook

1. Trefethen, Lloyd N., and David Bau III. *Numerical linear algebra*. Vol. 50. SIAM, 1997.
2. Eldén, Lars. *Matrix methods in data mining and pattern recognition*. Vol. 4. SIAM, 2007.

## Reference

1. Watkins, David S. *Fundamentals of matrix computations*. Vol. 64. John Wiley & Sons, 2004.
2. Demmel, James W. *Applied numerical linear algebra*. Vol. 56. SIAM, 1997.
3. Golub, Gene H., and Charles F. Van Loan. *Matrix computations*. Vol. 3. JHU press, 2012.

4. Cullen, Charles G. *An introduction to numerical linear algebra*. PWS Publishing Company, 1994.



IIT Mandi  
Proposal for a New Course

Course Number : DS404  
Course Name : Information Security and Privacy  
Credits : 3-0-0-3  
Prerequisites : DS203-Mathematical Foundations of Data Science I  
Intended for : B.Tech.  
Distribution : Discipline core for B. Tech. Data Science and Engineering,  
Discipline elective for B. Tech. Computer Science and Engineering,  
Electrical Engineering, Free elective for other B. Tech. disciplines  
Semester : Even/Odd.

Objective: During the last two decades, there has been a major paradigm shift in generation, processing, communication, and storage of information from predominantly analog domain to digital domain for the reasons such as ease of implementation, better efficiency, greater robustness against noise, and enhanced performance and security. This shift has not only resulted in opening up exciting new possibilities in numerous areas of sciences, engineering, and humanities, but have also created plethora of possibilities for the misuse of this data, raising serious security, privacy and ethical challenges. To address these challenges, DSE curriculum must not only introduce the students to spectrum of such challenges, but also equip them with various concepts, tools, techniques. This will enable the students to better understand information security, privacy, and ethical challenges and appreciate the current developments at the frontiers of these areas, both in theory and application, and prepare them to contribute to further advancement of such frontiers.

On completion of this course, students should be able to demonstrate their understanding of and apply methods of information security, privacy, and ethics to subsequent courses in data mining, pattern recognition, knowledge representation, information systems, to name a few. In particular, students should be able to

- demonstrate understanding and awareness of information security, privacy, and ethical issues in a given application scenario.
- propose practical solutions to address such issues using relevant concepts, tools, and techniques

Course modules with Quantitative lecture hours:

1. Introduction to information security: (8 lectures)  
Information security models; attacks, threats, vulnerabilities, and risks. Operations security: Haas' Laws.



Identification and authentication: identity verification, falsifying identification, multifactor and mutual authentication, passwords, biometrics, hardware tokens, performance evaluation.

Authorization and access control: principle of least privilege, access control lists, and access control methodologies, physical security and access controls.

Auditing and accountability: non-repudiation, deterrence, intrusion detection and prevention, logging, monitoring, assessments.

2. Cryptography: (8 lectures)  
Protocols (key exchange, public key cryptography, secret sharing), techniques (key length, key management, etc), cryptographic algorithms (mathematical background, data encryption standard, block and stream ciphers, public-key, digital signatures).
3. Network security: (6 lectures)  
Protecting networks and network traffic, mobile device security, network security tools.
4. Operating system security: (4 lectures)  
OS hardening, protecting against malware, firewalls and host intrusion detection, OS security tools.
5. Application security: (6 lectures)  
Software development vulnerabilities, web security, database security, and application security tools.
6. Information privacy: (6 lectures)  
Static and dynamic data anonymization and threats to anonymization, privacy in synthetic and test data, privacy regulations.
7. Information Ethics: (4 lectures)  
Ownership, privacy, anonymity, validity, algorithmic fairness, societal consequences, code of ethics, attributions.

Textbook Books:

1. Andress, J. and Winterfeld, S., *The Basics of Information Security*, 2/e, Syngress, 2014.
2. Venkataraman, N. and Shriram, A., *Data Privacy: Principles and Practice*, Chapman and Hall/CRC, 2016.

Reference Books:

1. Guise, P. D., *Data Protection*, Routledge, 2017.
2. Katz, J. and Lindell, Y., *Introduction to Modern Cryptography*, Chapman and Hall/CRC, 2015.
3. Torra, V., *Data Privacy: Foundations and the Big data Challenge*, Springer, 2017.
4. Weigand, A., *Data for the People*, Basic Books, 2017.



IIT Mandi  
Proposal for a New Course

Course Number : DS302  
Course Name : Computing for Data Science  
Credits : 2-0-2-3 (L-T-P-C)  
Prerequisites : None  
Intended for : UG  
Distribution : Discipline core for B. Tech. Data Science and Engineering, Not allowed to B.Tech. CSE, Discipline elective for B. Tech. Electrical Engineering, Free elective for other B. Tech. disciplines.  
Semester : Even/Odd

Preamble:

One of the important problems in data science is how to design computing systems that can deal with various sources of data, and can scale to huge volumes of data. This course is designed to give basic understanding of storage and computing systems at the logical and physical level of abstraction. Relevant topics from Operating Systems, Computer Organization and Databases are fused in this course to fulfil the above course objective. On completion of the course, students should be able to understand how data is represented in the computer, the different memory hierarchies and their performance, trade-offs between using processes and threads for applications, concepts of scheduling and different data models like Relational and NoSQL.

Course Modules with Quantitative lecture hours:

Basics of Computer Organization (8 lectures)  
Data representation, machine code, computer arithmetic, code compilation, memory organization and management, memory and run time performance optimization

Introduction to Operating Systems (8 lectures)  
Responsibilities of OS; process & thread management: process model, states and its structure, process creation and termination, thread models and issues, User/Kernel level threads; inter-process communication, process synchronization, and process scheduling; file systems.

Introduction to Databases (8 lectures)  
Information modeling, ACID properties and Transactions, Trade-offs between Relational Databases and NoSQL, Data Manipulation Language SQL

Scalable data processing using MapReduce  
Hadoop Distributed File System, MapReduce programming model

(4 lectures)

Text book:

1. Stallings, William. *Computer Organization and Architecture*, Global Edition. Pearson Education Limited, 2015.
2. Silberschatz, Abraham, Greg Gagne, and Peter B. Galvin. *Operating system concepts*. Wiley, 2018.
3. Elmasri, Ramez, and Sham Navathe. *Fundamentals of database systems*. Pearson, 2017.

Reference Books:

1. Forouzan, Behrouz, Catherine Coombs, and Sophia Chung Fegan. *Introduction to data communications and networking*. McGraw-Hill, Inc., 1997.
2. Ramakrishnan, Raghu, and Johannes Gehrke. *Database management systems*. McGraw Hill, 2000.
3. Carl Hamacher, V., Zvonko G. Vranesic, and Safwat G. Zaky. *Computer organization*. 2004.



IIT Mandi  
Proposal for a New Course

Course Number : DS403  
Course Name : Introduction to Statistical Learning  
Credits : 2-0-2-3 (L-T-P-C)  
Prerequisites : DS201 - Data Handling and visualization or equivalent,  
DS303 – Statistical Foundations of Data Science or equivalent,  
DS402 – Matrix Computations for Data Science  
Intended for : UG  
Distribution : Discipline core for B. Tech. Data Science and Engineering,  
Discipline elective for B. Tech. Computer Science and Engineering,  
Electrical Engineering, Free elective for other B. Tech. disciplines  
Semester : Even/Odd

**Preamble:** Data science involves using the scientific methods to process the data to extract knowledge and insights from data in various forms, both structured and unstructured. Vast amounts of data are being generated in many fields, and the data analyst's job is to make sense of it all: to extract important patterns and trends. This involves learning from data. This course intends to provide fundamental ideas and techniques in learning from data in the statistical framework.

**Objective:** After a course on data handling and visualization, and course(s) on statistical and mathematical foundations of data science, the students acquire familiarity with data in various forms, their representations, statistical and mathematical properties for analysing the data. This introductory course aims to provide foundations to different techniques for learning from useful information/patterns and trends from data. This course provide rigorous theoretical foundations to those techniques and integrate those with practical applications in various fields. However, the course shall strive to introduce relevant applications as and when needed to motivate/illustrate various topics. This course also aims at providing practical implementation of different techniques used for learning from data and making predictions on the real world data.

On completion of this course, the student should be able to

- Understand the different learning mechanisms like supervised and unsupervised learnings
- Learn to analyse data to gain insights using an appropriate learning algorithm under a given task and context
- Learn various learning algorithms for tasks such as regression, classification and clustering
- Evaluate the learning algorithms on the data from different areas and disciplines and make sense from them



Course modules with Quantitative lecture hours:

1. Introduction to learning from data: (2 lecture)  
Introduction to supervised learning and unsupervised learning.
2. Supervised learning: Regression (6 lectures)  
Linear regression models and least squares, Shrinkage methods: ridge regression and the LASSO.
3. Supervised learning: Classification (8 lectures)  
Logistic regression, nearest neighbour's method, Bayes classifier with unimodal and multimodal density - maximum likelihood estimation, expectation-maximization (EM) algorithm; decision trees, support vector machines (SVMs), basics of neural networks
4. Model Assessment and Selection: (6 lectures)  
Bias, variance and model complexity, The Bayesian approach, AIC and BIC, cross-validation, bootstrap methods, hypothesis testing, confidence intervals, significance testing.
5. Unsupervised learning: (6 lectures)  
Introduction to association rules, clustering, and dimension reduction.

Lab Exercises:

- Lab to be conducted on a 2-hour slot. It will be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class. The topics taught in the theory course should be appropriately be sequenced for synchronization with the laboratory.

Textbooks:

1. Hastie, T., Tibshirani, R. and Friedman, J. The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Second Edition, Springer, 12<sup>th</sup> Reprint, 2017.

Reference books:

1. Duda, R. O., Hart, P. E. and Stork, D. G., Pattern Classification, John Wiley, 2001.
2. Bishop, C. M., Pattern Recognition and Machine Learning, Springer, 2006.
3. Theodoridis, S. and Koutroumbas, K., Pattern Recognition, Academic Press, 2009.

IIT Mandi  
Proposal for a New Course

Course Number : DS401  
Course Name : Optimization for data science  
Credits : 3-0-0-3 (L-T-P-C)  
Prerequisites : IC111-Linear Algebra, IC110-Engineering Mathematics, DS301-  
Mathematical Foundations of Data Science I  
Intended for : UG  
Distribution : Discipline core for B. Tech. Data Science and Engineering, Discipline  
elective for B. Tech. Computer Science and Engineering, Electrical  
Engineering, Free elective for other B. Tech. disciplines  
Semester : Even

**Preamble**

Optimization lies at the heart of data science. Most of the problems in data science and machine learning are formulated as optimization problems. Techniques such as regression, estimation, learning etc. used in data science when applied to large scale data sets need efficient optimization techniques to find the solution. This course is meant as a first course in optimization for the undergraduate data science and engineering program. The first part of this course gives a strong foundation on convex optimization. An exposure to typical algorithms and acceleration methods used in data science as well as machine learning are provided in the second part. An expertise in these topics will prepare the student for dealing with advanced optimization methods used in data science and machine learning.

On completion of this course, students should be able to demonstrate their understanding of and apply various concepts of optimization in DSE and subsequent courses in statistics, Pattern recognition, and Deep learning.

In particular, students should be able to

- understand concepts related with convex optimization and optimality conditions.
- understand some of the modern powerful and efficient algorithms to solve problems originating in data science.
- have familiarity with algorithms dealing with problems in data science having non convex optimization formulation

Course modules with Quantitative lecture hours:

Affine sets, convex sets, cone, examples – hyperplanes, halfspaces, polyhedra, simplexes, positive semidefinite cones. Operations that preserve convexity. Separating and supporting hyperplanes. Dual cones.

(6 lectures)



Convex function, first and second order conditions, epigraph, operations that preserve convexity, conjugate function.

(6 lectures)

Convex optimization - linear, quadratic, geometric, conic, semidefinite programming. Formulation of - unconstrained, equality constrained, inequality constrained and both - problems.

(7 lectures)

Duality - Lagrange dual function, bounds on the optimal value. Lagrange dual problem, weak and strong duality, optimality conditions.

(8 lectures)

Gradient methods - gradient descent, Lipschitz functions, smooth functions, projected gradient descent, Frank-Wolfe algorithm, Chebyhsev iterations, conjugate gradient, Nesterov's accelerated gradient descent. Dual gradient ascent, ADMM.

(10 lectures)

Nonconvex optimization - alternating minimization and expectation maximization algorithms, convex relaxations.

(5 lectures)

Textbook:

1. Boyd, Stephen, and Lieven Vandenberghe. *Convex optimization*. Cambridge university press, 2004.

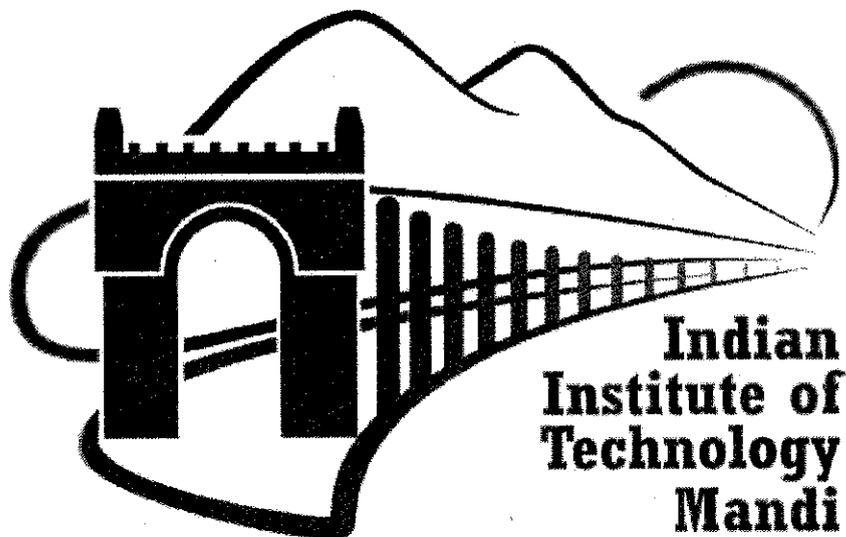
Reference books:

1. Yurii, Nesterov, *Introductory lectures on convex optimization: a basic course*. Kluwer Academic Publishers, 2004.
2. Luenberger, D. G., and Y. Ye. *Linear and nonlinear programming*, Springer New York, 2008.
3. Nocedal, Jorge, and Stephen Wright. *Numerical optimization*. Springer Science & Business Media, 2006.





**Proposal**  
**For**  
**B.Tech-MTech Integrated Dual Degree Programme**  
**In**  
**Bioengineering**



**School of Basic Sciences,**  
**School of Computing and Electrical Engineering,**  
**School of Engineering,**  
**Indian Institute of Technology Mandi**

## **Integrated Dual degree (IDD) B.Tech and M.Tech programme in Bioengineering**

### **Preamble to the programme:**

Bioengineering integrates physical, chemical, mathematical, computational and life sciences with core engineering principles for the study of biology, medicine and health systems and for the application of technology to improving health and quality of life. It creates knowledge from the molecular to organ systems levels, develops materials, devices, systems, information approaches, technology management, and methods for assessment and evaluation of technology, for the biological applications. The discipline of bioengineering has evolved drastically over the past 50 years, seemingly encompassing all fields that include bioelectric phenomena, bioinformatics, biomaterials, biomechanics, bioinstrumentation, biosensors, biosignal processing, biotechnology, computational biology, medical imaging, etc. The B.Tech and M.Tech dual degree programme on Bioengineering strives to train students in the field of physical, chemical mathematical and biological sciences together with engineering principles for the development of technology aimed at providing diagnostic, therapeutic and assistive and analytical support to biological systems. The programme strives to train the students in the field of basic electrical and mechanical engineering disciplines together with principles in physical, chemical, mathematical, computational and biological sciences for inculcating knowledge enabling them in developing and deploying Bioengineering technologies in various fields.

MTech allows the Bioengineers to specialise in four advanced focused areas:

- a) Biomedical Engineering aimed at gaining expertise in the areas of diagnostics, therapeutic and assistive support for healthcare applications.
- b) Agricultural Automation Technology aimed at providing automation and assistive support to agricultural practices.
- c) Environmental Science and Engineering aimed at training bioengineers to develop environment friendly processing technologies involving bio-organisms.
- d) Computational Bioengineering aimed at both developing algorithms and models to understand biological systems and processes.

The curriculum will impart training to budding students that will cater to the requirements of Bio-based industries.

### **M.Tech Specializations:**

1. Biomedical Engineering
2. Agro-Technology
3. Environmental Science and Engineering
4. Computational Bioengineering



**Selection:** Candidates will be selected through Joint Entrance Examination (Advanced) based on merit list.

**Eligibility:** Candidates must have completed (10+2) with Physics, Chemistry, Mathematics as their subjects.

**Provision of Scholarship in 5<sup>th</sup> year:** GATE (BT/BME\*/XL) qualified candidates are eligible for scholarship in the 5<sup>th</sup> year. Candidates having CGPA greater than 8.0 up to and including the 8<sup>th</sup> semester will be given a waiver to the GATE qualification for MHRD scholarship as per MHRD norms.

\*Proposal for GATE paper in BME is under consideration and likely to start from 2020.

**Duration:** 10 semesters. The degrees B.Tech in Bioengineering and M.Tech in specialised areas (Biomedical Technology or Computational Biology) will be awarded on completion of M.Tech.

#### **Objectives of the programme:**

1. Assimilate knowledge of physical, mathematical and biological sciences together with engineering principles for the development of diagnostic, therapeutic and assistive technologies as well as developing algorithms and models to understand biological systems and processes.
2. Train manpower for industries dedicated to technologies applied to biological systems.
3. Develop manpower to apply engineering concepts and techniques to the investigation and exploration of biological processes.
4. Train manpower capable of solving problems related to preventive medical approaches, automation based agricultural practices, environmental friendly bioprocesses and computational techniques for understanding biological systems.

#### **How is this programme different?**

1. Strong engineering emphasis.
2. Freedom to choose between multiple specializations.
3. Industrial involvement in teaching courses.
4. Wide market opportunities.
5. Scope of semester exchanges with foreign universities

**Branch change policy:** The existing change of branch policy at IIT Mandi will be applicable to students enrolled in the IDD (Bioengineering) programme after their 1<sup>st</sup> year subject to the condition that at least 20 students will remain enrolled in the IDD (Bioengineering) programme after branch change. However, there is no exit option available after 4<sup>th</sup> year for a single B.Tech degree in Bioengineering. This is in compliance with the existing practises of IIT s towards Integrated Dual Degree programmes.

#### **Graduation requirements:**

A student can complete B.Tech (Bioengineering) and M.Tech in X (X=Biomedical Engineering/Agro Technology/Environmental Science and Engineering/Computational Bioengineering) if:

1. He/she has earned 196 credits comprising of 160 credits of IC core, discipline core, HSS basket courses, free electives, M.Tech core and M.Tech discipline electives, and
2. He/she has completed 1 credit of Technical Communication, 1 credit of Research Methodology, 0 credits of Bioethics and Regulatory Affairs, 4 credits of Mini project, Term Paper and Seminar, and
3. He/she has completed 30 credits of M.Tech dissertation.
4. In case a student chooses courses belonging to different baskets of M.Tech core and discipline electives, he/she can earn an M.Tech degree in Bioengineering only.

**Core faculty members:**

1. Dr. Tulika Yadav (Spl: Bioinformatics, next generation sequencing technologies)
2. Dr. Shyam Kumar Masakapalli (Spl: Metabolic Systems Biology – Metabolomics and Fluxomics, NMR and GC-MS)
3. Dr. Amit Prasad (Spl: Immunology and microbiology)
4. Dr. Prosenjit Mondal (Spl: Molecular endocrinology and metabolism)
5. Dr. Amit Jaiswal (Spl: Nanobiotechnology)
6. Dr. Rajanish Giri (Spl: Biophysics and protein folding, T Cell Engineering, Protein Engineering)
7. Dr. Neha Garg (Spl: Cancer Biology, Stem Cells)
8. Dr. Shweta Tripathi (Spl: Virology, Innate Immunity, Cancer Biology)
9. Dr. Sarita Azad (Spl: Epidemics and Bio-surveillance)
10. Dr. Syed Abbas (Spl: Ecological modelling)
11. Dr. Rajesh Ghosh (Spl: Biomechanics)
12. Dr. Mohammed Talha (Spl: Biomechanics)
13. Dr. Sunny Zafar (Spl: Biomechanics)
14. Dr. Gaurav Bhutani (Spl: Biomechanics)
15. Dr. Anil Kr. Sao (Spl: Medical Image Analysis)
16. Dr. Arnav Bhavsar (Spl: Medical Image Analysis)
17. Dr. Aditya Nigam (Spl: Medical Image Analysis)
18. Dr. Renu Rameshan (Spl: Medical Image Analysis)
19. Dr. Srikant Srinivasan (Spl: IoT, Plant phenotyping)
20. Prof. Ajit Annachhatre (Spl: Environmental Science and Engineering)
21. Dr. Shubhajit Roy Chowdhury (Spl: Biomedical Systems)

**Curriculum:**

**Semester I**

Course Code	L-T-P-C	Course Name
IC110	2.5-0.5-0-3	Engineering Mathematics
IC152	3-0-3-5	Data Science I
IC160	3-0-0-3	Electrical Systems Around Us
IC160P	0-0-3-2	Electrical Systems Around Us Lab
IC140	2-0-3-4	Graphics for Design
IC101P	0-0-3-2	Reverse Engineering
HS106	3-0-0-3	English I

HS10X	1-0-0-1	Creative Understanding
<b>Total</b>	<b>23 credits</b>	

### Semester II

Course Code	L-T-P-C	Course Name
IC111	2.5-0.5-0-3	Linear Algebra
IC141	2-0-0-2	Product Realization Technology
IC141P	0-0-3-2	Product Realization Technology Lab
IC161	3-0-0-3	Applied Electronics
IC161P	0-0-3-2	Applied Electronics Lab
IC252	3-0-2-4	Data Science II
HSXX1	3-0-0-3	HSS Language competence basket course
IC142	3-1-0-4	Engineering Thermodynamics
<b>Total</b>	<b>23 credits</b>	

### Semester III

Course Code	L-T-P-C	Course Name
IC260	2.5-0.5-0-3	Signals and systems
IC136	3-0-0-3	Understanding Biotechnology and its applications
IC3XX	2-0-2-3	Data Science III
IC121	3-0-0-3	Mechanics of Particles and Waves
IC130	3-0-0-3	Applied Chemistry for Engineers
IC130P	0-0-3-2	Applied Chemistry Practicum
IC241	3-0-0-3	Material Science for Engineers
HSXX2	3-0-0-3	HSS course
<b>Total</b>	<b>23 credits</b>	

### Semester IV

Course Code	L-T-P-C	Course Name
IC201P	0-0-6-4	Design Practicum
IC240	1.5-1.5-0-3	Mechanics of Rigid Bodies
IC242	2.5-0.5-0-3	Continuum mechanics
IC222P	0-0-3-2	Physics Practicum
IC221	3-0-0-3	Foundations of Electrodynamics
BEXX1	3-0-2-4	Biology-I
BEXX2	2-0-2-3	Biology-II
<b>Total</b>	<b>22 credits</b>	

**Semester V**

<b>Course Code</b>	<b>L-T-P-C</b>	<b>Course Name</b>
BEXX3	2-0-2-3	Biology-III
BEXX4	3-0-0-3	Physics and modeling of biological systems
BEXX5	2-0-2-3	Computational Biology
BEXX6	1-0-2-2	Biostatistics
BEXX7	1-0-0-0	Bioethics, and Regulatory affairs
BEXX8	3-0-0-3	Biomaterials
BEXX9	3-0-2-4	Biomechanics
HSXX2	3-0-0-3	HSS course
<b>Total</b>	<b>21 credits</b>	

**Semester VI**

<b>Course Code</b>	<b>L-T-P-C</b>	<b>Course Name</b>
BEXX10	3-0-2-4	Biosensing and Bioinstrumentation
BEMC1	3-0-0-3	M.Tech Core-I
BEMC2	3-0-0-3	M.Tech Core-II
BEXE1	3-0-0-3	Discipline Elective-I
HSXX3	3-0-0-3	HSS course
FFXX1	3-0-0-3	Free Elective-I
<b>Total</b>	<b>19 credits</b>	

**Semester VII**

<b>Course Code</b>	<b>L-T-P-C</b>	<b>Course Name</b>
ITXX1	0-0-2-2	Industrial Internship
BEXE2	3-0-0-3	Discipline Elective-II
BEXE3	3-0-0-3	Discipline Elective-III
HSXX4	3-0-0-3	HSS Course
FFXX2	3-0-0-3	Free Elective-II
FFXX3	3-0-0-3	Free Elective-III
HS541	1-0-0-1	Technical Communication
<b>Total</b>	<b>18 credits</b>	

**Semester VIII**

<b>Course Code</b>	<b>L-T-P-C</b>	<b>Course Name</b>
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BEXE4	3-0-0-3	Discipline Elective-IV
BEXE5	3-0-0-3	Discipline Elective-V
HSXX5	3-0-0-3	HSS Course
FFXX4	3-0-0-3	Free Elective-IV
RM600	1-0-0-1	Research Methodology
DPXX1	0-0-8-4	Mini Project, Term Paper and Seminar
<b>Total</b>	<b>17 credits</b>	

#### Semester IX

Course Code	L-T-P-C	Course Name
BEXE6	0-0-30-15	M.Tech Dissertation
<b>Total</b>	<b>15 credits</b>	

#### Semester X

Course Code	L-T-P-C	Course Name
BEXE7	0-0-30-15	M.Tech Dissertation
<b>Total</b>	<b>15 credits</b>	

**Total: 196 Credits**

#### M.Tech Core courses and Electives leading to specializations:

##### A. Biomedical Engineering:

##### M.Tech Core:

1. Anatomy and Physiology
2. Biomedical Systems

##### Discipline Electives (any five):

1. Medical Imaging Systems and Analysis
2. Medical Devices and Packaging
3. Analytical bio-techniques (existing)
4. Biomedical Instrumentation
5. Embedded Systems (existing)
6. Neuroscience and Cognitive Science
7. Optical Microscopy
8. Next generation biomanufacturing
9. Tissue Engineering
10. Regenerative Medicine

11. Nanobiotechnology (existing)
12. Biomedical Image and Signal Analysis
13. Biosolid Mechanics
14. Biofluid mechanics

**B. Agro-Technology:**

**M.Tech Core:**

1. Precision Farming
2. IoT for agriculture

**Discipline Electives (any five):**

1. Plant phenotyping
2. Machine learning for plant phenotyping
3. Plant genotyping
4. Embedded Systems
5. Agricultural Biotechnology (Crop breeding, Genetically modified crops)
6. Bioprocess Technology
7. Post-harvest technology and management
8. Design of farm machinery/Farm mechanisation
9. Agroresidue management
10. Green House Technology
11. Storage and enhancing shelf life
12. Food processing Technologies and devices
13. Agro-cultivation technologies (Hydroponics, Aquaponics etc)
14. Technology for Agribusiness and marketing of produce
15. Irrigation technologies

**C. Environmental Science and Engineering:**

**M.Tech Core:**

1. Microbiology for environmental applications
2. Environment friendly bioprocesses

**Discipline Electives (any five):**

1. Solid waste management
2. Waste water management
3. Air pollution control techniques
4. Waste reuse and recycle
5. Toxic and hazardous waste management
6. Water quality management

7. Modeling of waste water treatment system
8. Environmental quality management

**D. Computational Bioengineering:**

**M.Tech Core:**

1. Bioinformatics
2. Analysis and Design of Algorithms

**Discipline Electives (any five):**

1. Next generation sequencing
2. Biomedical Image and Signal Analysis
3. Computational Neuroscience
4. Deep learning
5. Pattern Recognition
6. Neuroscience and Cognitive Science
7. Modeling of bioprocess parameters
8. Transcriptomics
9. Proteomics
10. Metabolomics
11. Fluxomics
12. Biological modeling and simulation
13. Computational drug discovery
14. Finite Element Methods



Course Name: **Biology-I**

Course Number:

Credit: 3-0-2-4

Prerequisites:

**1. Course Preamble:**

The objective of the course is to provide students with a comprehensive and concise overview of biological science with emphases on its relationship with bio-engineering.

**2. Course Outline:**

**Module 1: cells: The fundamental units of life** [ 10 hours ]  
The structure and ultrastructure of the cell (the prokaryotic cell and the eukaryotic cell). Membrane enclosed Organelles (nucleus, chloroplast, mitochondria, ribosome etc)  
Model organisms (Yeast; simple eukaryotic cell, Arabidopsis; model plant, Fish/worms/mice; model animal

**Module 2: Cell Membranes and membrane transport** [ 10 hours ]  
Membrane structure (lipid bilayer, and membrane protein) , principles of transmembrane transport, Transporter and their function

**Module 3: cytoskeleton and cell motility** [ 10 hours ]  
Intermediate filaments, microtubules, actin filaments, Extra Cellular Matrix

**Module 4: The cell-division cycle** [ 12 hours ]  
Overview of the cell cycle, The Eukaryotic Cell Cycle, prokaryotic cell division, Mendel and the law of inheritance

**Lab:** [28 hours]

Subcellular fractionation and isolation of organelles •Sub cellular localization of proteins •Techniques for the propagation of eukaryotic and prokaryotic cells Culture and Gram's staining of Gram positive and negative bacteria, • cell proliferation and apoptosis monitoring •Experiments to study active and passive transports across cell membranes

**3. TEXT BOOKS**

□ Molecular Biology of the Cell - 5th Edition; 2015 - Bruce Alberts et al - Garland Science

□ Molecular Cell Biology - 7th Edition; 2016 - Harvey Lodish, Arnold Berk & Chris A. Kaiser - W.H. Freeman

□ Lewin's Cells - 3rd Edition - Cassimeris/Lingappa/Plopper -- Johns & Bartlett Publishers

#### REFERENCES

#### 4. Reference

.Campbell Biology (11th Edition) by Jane B. Reece, Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Robert B. Jackson, Benjamin Cummings, 2015



**Course Name: Biology-II**

**Course Number:**

**Credits:2-0-2-3**

**Prerequisites: Biology-I**

**1. Course Preamble:**

The objective of the course is to provide students with a comprehensive and concise overview of biological science with emphases on its relationship with biomedical engineering.

**2. Course Outline:**

**Module 1: Cells: Chemical components of cells** [ 7 hours ]  
Chemical bonds, small molecules in cells, macro molecules in cells

**Module 2: From DNA to protein: how cells read the genome** [ 6 hours ]  
From DNA to RNA, from RNA to Protein, control of gene expression

**Module 3: How cells obtain energy from food** [ 6 hours ]  
Breakdown and utilization of sugars and fats, energy generation in mitochondria and chloroplasts, electron transport and proton pump, chloroplast and photosynthesis

**Module 4: cell-cell communication and protein transport** [ 9 hours ]  
General principles of cell signaling, G-protein couple receptor, enzymes-couple receptor, protein sorting, vesicular transport, endocytic pathways

**Lab:** [28 hours]

DNA/RNA isolation •cDNA synthesis, qRT PCR •ELISA to measure 2<sup>nd</sup> messenger • side directed mutagenesis assay •glucose output assay, Intracellular lipid staining

**3. TEXT BOOKS**

□ Molecular Biology of the Cell - 5th Edition - Bruce Alberts et al - Garland Science

**REFERENCES**

□ Molecular Cell Biology - 7th Edition - Harvey Lodish, Arnold Berk & Chris A. Kaiser - W.H. Freeman

□ Lewin's Cells – 2nd Edition – Cassimeris/Lingappa/Plopper – Johns & Bartlett Publishers.

**Course Name: Biology-III (Biochemical reactions and Bioprocessing)**

**Course Number:**

**Credit: 2-0-2-3**

**Prerequisites: IC136**

**Course Preamble:**

This course introduces the fundamentals of biochemical reactions and the principles of bioprocessing. The first part of the course will give an appreciation of the key roles the enzyme driven biochemical reactions in different biological systems play in terms of bioenergetics, cellular metabolism and sustainable biosynthesis of biomolecules that serve wide applications. The second part introduces bioprocessing principles and related parameters that would influence cellular growth kinetics in typical bioreactor operation conditions. The laboratory component covering key areas from both the modules will provide basic hands-on understanding of the enzyme kinetics and bioprocessing.

**Course Outline:**

**Module 1: Fundamentals of Biochemical reactions and Enzymology**

Bioenergetics - exergonic and endergonic reactions, redox reactions, high energy compounds, cofactors – ATP, NAD, NADH, NADP, NADPH etc and their significance.

Enzyme kinetics, mechanism, Regulation, Multienzyme systems, Enzyme turnover, Enzyme inhibition.

Case studies of enzyme applications in Industry, Health, Food and Environment

Metabolism – Anabolism and catabolism; Overview of central and secondary metabolism.

Metabolic pathways and their analysis (qualitative and quantitative)

**Module 2: Introduction to Bioprocessing and bioreactors**

Bioprocessing – definition, controls and parameters such as Oxygen transfer, redox, pH etc.

Stoichiometry and Kinetic Model of Cell Growth. Monod Model and its Derivatives.

Fermentation technology and Downstream processing

Bioreactor types and their Operating Modes

**Labs:**

Enzyme kinetics – Effect of substrate concentration, Effect of temperature, Effect of pH, Enzyme inhibitory assay, Demonstration of Bioreactor, Microbial cultivation in a batch and estimation of growth rates, Fermentation and downstream analysis/processing of end products

## TEXT BOOKS

- Lehninger Principles of Biochemistry, David L. Nelson and Michael M. Cox, Seventh Edition 2017; ISBN-10: 1-4641-2611-9; ISBN-13: 978-1-4641-2611-6
- **Fundamentals of Modern Bioprocessing, Sarfaraz K. Niazi, Justin L. Brown 1<sup>st</sup> edition, CRC Press 2017; ISBN 9781138893290**

Similarity Content Declaration with Existing Courses – 20%, BY513



**Course Name: Physics and modeling of biological systems**

**Course Number:**

**Credits: 3-0-0-3**

**Prerequisites:** IC160 Electrical systems around us, Biology I.

**Preamble:** The course aims at modeling biological systems in the light of circuit theory and control theory and uses those models for further analysis of signal extraction from biological systems. The course begins with a description of circuit theory and control theory and then applies those theories in the modeling and analyses of biological systems. Some discussion on signal extraction from biological systems and its initial conditioning will be provided at the end.

**Course Objectives:**

1. Understand the basic concepts of networks and control systems
2. Apply the concepts of networks and controls in biological systems
3. Understanding the signal acquisition from biological systems based on its dynamical behavior.

**Course content:**

1. **Transport in an infinite medium:** Flux, fluence and continuity, drift and diffusion, Fick's laws of diffusion, time dependent solutions for diffusion and solvent drag, steady state diffusion to a spherical cell, modeling of excretion of metabolites from a spherical cell. 7 hours
2. **Transport through neutral membranes:** Membranes, Osmotic pressure in gases and liquids, transport of solute and solvents from root to leaves, modeling of edema, solute transport through a membrane. Examples from cellular systems, ion transport mechanism in cells, application of circuit theory to cell analysis – the cable model, electrotonus model, Hodgkin Huxley model for membrane current, voltage changes in cell over space and time, biological networks. 10 hours
3. **Exterior potential:** Potential outside a long cylindrical cell, exterior potential for an arbitrary pulse, electrical properties of organs and organ-systems. 7 hours
4. **Biomagnetism:** Magnetic field of a cell in an infinite homogeneous conducting medium, electromagnetic induction, detection of weak magnetic fields, magnetic materials and biological systems, detection of weak magnetic fields. 8 hours
5. **Feedback and control:** Basics of control engineering – notion of open loop and closed loop systems, homeostasis, stability of systems, criteria of stability, example study in practical systems. 6 hours
6. **Molecular dynamics:** Simulation of biological molecules, cellular modeling, metabolic modeling, flux. 6 hours

**Text book:**

1. Introduction to Biomedical Engineering, Enderle, Blanchard and Bronzino, Elsevier Press, 2015.

**Reference books:**

1. Biomedical Circuits and Systems, Culurciello, CRC Press, 2017.
2. Electronic Device for Non Invasive Monitoring of Blood Glucose Levels, Khandolkar, Lambert Academic Publishing, 2018.



**Course Name: Computational Biology**

**Course Number:**

**Credit: 2-0-2-3**

**Prerequisites: IC136**

**Students intended for: B. Tech., M.Tech., M.S., and Ph.D.**

**Elective or Compulsory: Core**

**Semester:**

**Course Outline:**

**Objective:** The course is aimed at providing a basic understanding to the students about bioinformatics methods and their in-depth applications for solving biological problems. The course will include practical sessions for the students to help them master some of the bioinformatics techniques from hands-on experience. The course may also involve a project/term-paper development towards important biological problems within the purview of the course.

**Part I: Basic Bioinformatics**

*Introduction to Bioinformatics:* What is Bioinformatics? What are the applications of Bioinformatics?

*Introduction to Basic Programming:* Introduction to basic scripting and programming routinely used for bioinformatics analysis.

*Sequence and Molecular File formats:* Introduction to different file formats used for biological data. Sequence and molecular file conversion tools.

*Databases in Bioinformatics:* Introduction to different biological databases, their classification schemes, and biological database retrieval systems.

**Part II: Bio-algorithms and Tools**

*Sequence Alignments:* Introduction to concept of alignment, Scoring matrices, Alignment algorithms for pairs of sequences, Multiple sequence alignment.

*Gene Prediction Methods:* What is gene prediction? Computational methods of gene prediction.

*Molecular Phylogeny:* Introduction to phenotypic and molecular phylogeny. Representation of phylogeny, Molecular clocks, Methods of phylogenetic construction, statistical evaluation of the obtained phylogenetic trees.

*Pathways and Systems Biology*: Introduction to pathways and systems biology, Analysis of Pathways, Metabolic network properties, Metabolic control analysis, Simulation of cellular activities.

*Protein Structure Analysis*: Introduction to basic approaches for protein structure analysis and visualization.

**Lab Course content:**

1. Perl programming
2. Databases for Bioinformatics and format conversion
3. Sequence similarity (Local alignment)
4. Sequence similarity (Global alignment)
5. Gene prediction Prokaryotic
6. Gene prediction Eukaryotic
7. Phylogenetic analysis
8. Functional analysis (patterns, profiles, clusters etc)
9. Pathway analysis
10. Protein structure visualization

**Text Book:**

1. Bioinformatics: Methods and Applications Genomics, Proteomics, and Drug Discovery S.C. Rastogi, N. Mendiratta, P. Rastogi (3<sup>rd</sup> Edition) PHI Learning Private Limited New Delhi (2011)
2. Bioinformatics Principles and Applications. Z. Ghosh and B. Mallick Oxford University Press.

**Other References:**

1. Introduction to Bioinformatics. Arthur M. Lesk (3<sup>rd</sup> Edition) Oxford University Press.

**Articles:**

Latest research articles will be advised related to the topic being taught.

**Course Name: Biostatistics**

**Course Number:**

**Credits: 1-0-2-2**

**Prerequisites: Data Science II**

**Preamble:** This course is intended to cover fundamental concepts in biostatistics, data science in biology, and how to apply these concepts using the R statistical programming language. In general, this course will emphasize applied statistical theory on biological data analysis.

**Course content:**

1. Application of statistics in biological data analysis. Parametric, semi-parametric and non-parametric methods, survival analysis, longitudinal data analysis, linear mixed effect models. 4 hours
2. Multivariate Analysis: various types of classification, ANOVA, PCA, ICA. 4 hours
3. Epidemiological indicators of plant, animal and human health. 2 hours
4. Statistical issues with bio-experimental data and economic modeling for cost effectiveness evaluation, dynamic treatment regimes, assessment of diagnostic tests and instruments, analysis of sequential trials. 4 hours

**Lab:** Laboratory experiments on Plant, animal and human data analysis using R.

**Text book:**

1. Abhaya Indrayan and Rajeev Kumar Malhotra, Medical biostatistics, , Chapman and Hall, 2017.

**Reference book:**

1. Biostatistics and Epidemiology: A Primer for Health and Biomedical Professionals, Wassertheil-Smoler, Springer-Verlag 2014.
2. Design and Analysis of Clinical Trials: Concepts and Methodologies, Shein-Chung Chow, Jen-Pei Liu, 3<sup>rd</sup> edition, Wiley, 2016.



**Course Name: Bioethics and regulatory affairs**

**Course No.:**

**Credits: 1-0-0-0**

**Preamble:** This is a pass-fail course intended to serve as a broad introduction to the field of bioethics and regulatory affairs. The course will combine lectures with small-group case work that encourages students to explore ethical dilemmas in a faculty-supported, peer-educated environment. The course also provides a discussion on drug and pharmaceutical regulatory affairs.

1. **Introduction to Bioethics:** Ethics and ethical theory, justice and rights, liberty and morality, Principlism, Virtue ethics, Ethics of Care, Human Rights 2 hours
2. **Ethics of research with human subjects:** The Nuremberg code, Declaration of Helsinki, the Belmont report, ethics of investigator-participant relationship, problems of randomized clinical trial, purpose and function of institutional review board, informed consent, research with those with impaired capacity for consent and participant panel, research involving persons at risk for impaired decision making 4 hours
3. **Drug regulatory affairs:** Pharmaceutical regulatory affairs, national regulatory affairs, drug approval and international drug regulations, regulatory affairs of controlled drug delivery system, regulatory requirements for product approvals, environmental concerns and regulations. 4 hours

**Text Book:**

1. Ronald Munson, *Intervention and Reflection: Basic Issues in Medical Ethics* 10<sup>th</sup> Edition, Cengage Learning, 2018

**Reference book:**

1. Atul Gawande, *Being Mortal: Medicine and What Matters in the End*, Henry Holt and Co. , 2017.

**Course Name: Biosensing and Bioinstrumentation**

**Credits: 3-0-2-4**

**Prerequisites: Physics and modeling of biological systems**

**Preamble:** The course aims at studying techniques of measurement, obtaining signals from biological systems and processing those signals for estimating various biological parameters. The general principles of measurements, sensing and instrumentation will be applied in various bio-instruments. The students will also have a current background on the basic principles of key analytical biotechnologies, and how these technologies allow sensitive and accurate detection, purification, and characterization of biomolecules.

**Course Objectives:**

1. Understand the basic concepts of measurement, sensing and instrumentation
2. Apply the concepts of sensing and instrumentation in biological systems
3. Understanding the signal acquisition from biological systems based on its dynamical behavior.
4. Detect and characterize biomolecules

**Course content:**

1. **Measurement:** SI units, systematic and random errors in measurement, expression of uncertainty - accuracy and precision index, propagation of errors, DC potentiometer; bridges for measurement of R, L and C, Q-meter. 4 hours
2. **Sensors:** Physical biosensors and associated signal conditioning circuits; Chemical biosensors; Antibody based biosensors, DNA based biosensor, Immunoassays for plant and animal pathogen detection, Enzyme linked immune-sorbent assays (ELISA), bio-luminescent technologies for pathogen detection, Optical sources and detectors: LED, Photo-diode, p-i-n and avalanche photo diode, basics of magnetic sensing; Interferometer: applications in metrology; basics of optical sensing and LASER. 10 hours
3. **Biosignals:** Origin, nature, and types of Biosignals, Principles of sensing physiological parameters from plants and animals, types of transducers and their characteristics, Electrodes for bioelectric signals, Bioelectric signals and their characteristics. Chemical and electrochemical biosignals, optical signals. 4 hours
4. **Bioinstrumentation:** Biopotential Amplifiers, Noise and artefacts and their management, Electrical Isolation (optical and electrical) and Safety of bio-instruments. Generation, Acquisition, and signal conditioning and analysis of biosignals. Principles of measuring blood pressure, bioamperometric enzyme electrode. 10 hours

- 5. Analytical bio-techniques:** Principles and applications of UV-Visible-NIR spectroscopy, fluorescence spectroscopy, MR spectroscopy, basics of chromatographic techniques, imaging techniques – principles and applications of microscopy. 12 hours

**Lab:** Design of measurement circuits, ELISA test, extraction of bio-signals, amplification and isolation of bio-signals, phase contrast microscopy, chemoluminescence, fluorescence spectroscopy, MR spectroscopy, spectrophotometry.

**Text book:**

1. A.G. Webb, Principles of Biomedical Instrumentation, Cambridge University Press, 2018.

**Reference books:**

1. R.S. Khandpur, Biomedical Instrumentation – Technology and Applications, TMH, 2017.
2. S.C. Mukhopadhyay, A.L. Ekuakille, Advances in Biomedical Sensing, Measurements, Instrumentation and Systems, Springer-Verlag, 2018.
3. Principles of Fluorescence Spectroscopy by Lakowicz, Joseph R. (3rd Edition), 2006.
4. Instrumental Methods of Analysis, Willard, CBS publishers, 2015.

**Course Name: Biomechanics**

**Credits: 3-0-2-4**

**Preamble:** The course provides an overview of musculoskeletal anatomy, plant mechanics, the mechanical properties and structural behavior of biological tissues, and bio-dynamics. Specific course topics will include structural and functional relationships in tissues and organs; application of stress and strain analysis to biological tissues; analysis of forces in human function and movement; energy and power in human activity; introduction to modeling viscoelasticity of tissues

**Course Objectives:**

1. Understand the basic concepts of musculoskeletal anatomy, the mechanical properties and structural behavior of biological tissues and plants
2. Apply stress and strain analysis to biological tissues
3. Analyze the dynamics of movement and locomotion.

**Course content:**

1. **Introduction and Fundamentals:** What is Biomechanics? Anatomical Concepts in Biomechanics, free-body diagrams and equilibrium; linear and angular kinematics, kinetic equation of motion, work and energy method, application to biological systems: stress, strain, Modulus, strain energy, tension, compression, torsion, bending, buckling. 14 hours
2. **Tissues:** Plant tissues and animal tissues. Plant tissues – vascular bundles – xylem and phloem. Classification of animal tissues - hard tissue, soft tissue, properties of plant and animal tissues according to mechanics view point, Structure, Function, composition, material properties and modeling of tissues, Continuum Mechanics Concepts in Modeling of large deformation, Finite Element Modeling 14 hours
3. **Joints and Movements: Classification of joints, forces and stresses, biomechanical analysis joints, Gait, Joint replacement and reasons, Finite Element Modeling.** 6 hours
4. **Biofluid mechanics:** Flow properties of blood and others, Fluid flow in plants, Dynamics of fluid flow in the biological system - modeling and experimental approaches, Measurement/Estimation of In-vivo elasticity of fluid transporting vessels. 8 hours

**Lab:** Simulation and practical experiments based on the theory syllabus – root strength analysis, bones strength analysis - experimental and numerical analysis.

**Text Books:**

1. Basic Biomechanics of the Musculoskeletal System, by Nordin & Frankel

2. Biomechanics: Mechanical Properties of Living Tissues, by Fung
3. Plant Biomechanics: An engineering approach to plant form and function, by K. J. Niklas

**Reference Book:**

1. Berne & Levy Physiology, 6th Updated Edition, Elsevier, 2018.
2. Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation, by Ozkaya and Nordin
3. Principles of Biomechanics by Robert L.Huston, CRC Press



**Course Name: Biomaterials**

**Course Number:**

**Credit: 3-0-2-4**

**Prerequisites:** IC 136 Understanding Biotechnology and its Applications and IC 241 Materials Science for Engineers

**1. Course Preamble:**

The objective of this course is to build a solid foundation of knowledge for biomaterial science and technology. The target is to teach the physical and biological principles that serve as the scientific basis for understanding the interactions of biological molecules and cells with biomaterials employed for different biomedical applications.

**2. Course Outline:**

**Module 1: Introduction to Biomaterials (8 hours)**

Introduction to biomaterials and its history, Properties of Biomaterials- physico-chemical, mechanical, biocompatibility and biodegradability, Surface properties of biomaterials, Biological responses and Cell-Biomaterial interaction

**Module 2: Classes of Biomaterials (8 hours)**

Polymeric materials and blends, Biopolymers and hydrogels, Metal based biomaterials, Ceramics and bioglasses; Adhesive and sealants, Elastomers

**Module 3: Biomaterials Applications (20 hours)**

Applications of biomaterials in cardiology, nephrology, ophthalmology, dentistry and orthopaedics; Wound healing and dressing materials, skin substitutes and sutures, Applications of Biomaterials in Functional Tissue Engineering and drug delivery systems

**Module 4: Device development, Standards and regulatory compliance (6 hours)**

Biomaterial device development and Regulation, Voluntary consensus standards, Commercialization, corporate considerations, Ethical issues, Clinical trials, Entrepreneurship and post market considerations in biomaterials.

**3. Text Books**

1. Biomaterials Science (Third Edition), An Introduction to Materials in Medicine, ISBN 978-0-12-374626-9, Academic Press, Edited by: Buddy D. Ratner et al.

2. Advanced Biomaterials: Fundamentals, Processing and Applications; John Wiley & Sons, Inc., USA (ISBN: 978-0-470-19340-2), September, 2009.

3. Biomaterials Science and Biocompatibility, Fredrick H. Silver and David L. Christiansen, Piscataway, Springer, New Jersey.

4. Related journal articles

**Lab Space and Resources needed:** Three lab spaces are needed for:

- i. Biology Labs-I,II,III
- ii. Biomedical Engineering Lab (covering Biosensing and Bioinstrumentation, Biomedical Instrumentation, Biomechanics)
- iii. Computational Bioengineering Lab (covering Computational Biology, Biostatistics, Bioinformatics, etc)

**Reviewers' comments:**

1. Dr. Atul Minhas, Macquarie University, Australia



Atul Minhas atul.minhas@mq.edu.au via iitmandi.ac.in

Wed, Dec 5,  
2018, 2:29 AM

to Shubhajit

Dear Dr Shubhajit,

Congratulations on thinking about Bioengineering at IIT Mandi. It is certainly a major in very high demand. I have some quick comments

(1) Introduce at least one course per semester related with biomedical engineering

- at the moment there is no biomedical engineering course in semester 1 and 2
- Like MBBS 1st year, physiology must be taught in 1st year (may be 1st semester and 2nd semester courses as **Physiology-I** and **Physiology-II**, respectively)
- **Anatomy** as a separate course can come in semester III and **Systems Biology** in semester 4
- Semester V is very heavy, full of biomedical engineering courses, I do not know what will you cover in **Computational Biology**, however **Biostatistics** must be a separate course. So, you might want to move **Biomedical Measurements and Instrumentation** to second year (semester 4?)
- **Ethical Issues in Biomedical Engineering** must be taught in early stage (may be semester V), because this is the course which really inculcates the feeling of biomedical engineering to students. Otherwise, they would never understand the key difference between biomedical engineering and other engineering streams.

(2) **Biomedical Technology**

- What is the difference in the course contents between **Control Systems** and **Biomedical Systems**? **Control Systems** in biomedical engineering cannot be case as the typical course for electrical/electronics engineers. It must be **Biomedical Systems and Control** (refer to IIT Madras's course for MTech students).
- What are you covering in **Medical Imaging**? I recommend you make it **Medical Imaging Systems (X-ray, CT, PET, SPECT, MRI, Ultrasound)**. I am teaching this course at the moment in Macquarie.
- I do not see any explicit course in **Medical Image Processing** (which is expertise of Anil and others).

**Other specializations in your MTech are not my area, so I cannot comment on them.**

Hope my comments were helpful. Happy to help more if you are planning to work on these comments.

With warm regards,

Atul Singh Minhas  
Senior Lecturer in Biomedical Engineering

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Faculty of Science and Engineering, Macquarie University, North Ryde, Sydney, NSW 2109, Australia.

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2. Prof. Prasun Kumar Roy, IIT BHU, Varanasi

Dr. P K Roy <pkroy.bme@iitbhu.ac.in>

Sat, Dec 8,  
2018, 8:02



AM

to src

Dear Dr Roy Chowdhury,

Thank you for your mail about your new schema for the IDD Bio-Engg. program.

The proposal indeed looks attractive.

I think some points might be considered.

Recently, after the breakthroughs of the international initiatives as the Human Genome program and the Personalized Medicine Program, the discipline of Bio-Engineering has spawned such that there is equal importance to all the 3 components of the discipline: Biology, Medicine, Engineering.

It would be nice to give also give a good emphasis to both Biology as well as to Medicine (particularly diagnostic and therapeutics) aspects right from the initial year of your program. The program appears more loaded towards the "Engineering" fields. I think shifting some programs between the years may be needed, which I mention later.

Your effective teaching program is 4 years (the 5th year is for only MTech thesis).

In that teaching program's first 50% duration (i.e. the first 2 years), the course deals mainly with Engineering and allied fields, as Basic engineering/I.T./Computing/Physical sciences,. Basic Biology and Basic Medical areas may now be considered. From the bioscience perspective, in the first 2 years, you have only 2 biology subjects, both they are more technology/mathematics oriented, as Bio-"technology", and Systems Biology (this field is mostly Bio-mathematics).

It may be preferable to have courses in core biology in the first 2 years from the beginning, and at least 1 biological subject every semester. Is it possible to have a foundational course on "Molecular Biology and Genetics" in your First year (Genetics, DNA, RNA and Ribosome machine is very exciting to youngsters I find, if put from an "algorithm" and "machine" perspective). Also, is it possible to shift your "Cell biology and cellular processes" subject to the Second year (Medical students do similar courses in first year, after school).

We are having the Indian Academy of Neuroscience annual conference, in AIIMS Delhi, next November, 2019 (we organized this years conference here at BHU here last month). Your faculty and students are welcome to participate (<http://neuroscienceacademy.org.in/joinacademy.php#>)

Hope this may be useful to you.

It is a very good initiative that you are doing.

All the best,

Prasun

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Prof. Prasun Kumar Roy, MBBS, MRCR, FRSM, PhD; J.N. Tata Innovation Fellow (DBT, GOI).  
FNAE, FNASc, FNAMedSc.

Professor,  
Neuroscience & Neuro-Imaging Laboratory,  
School of Bio - Medical Engineering,  
Indian Institute of Technology, I. I. T.;



Banaras Hindu University (B.H.U.).

Varanasi 221 005, U.P., India. Email: [pkroy.bme@iitbhu.ac.in](mailto:pkroy.bme@iitbhu.ac.in), Cell 99108-31172.

Council Member, CTSI, International Neuroinformatics Coordination Facility, Karolinska Institute, Stockholm.  
Principal Investigator, National Consortium Program (Multimodal Brain Imaging), Ministry of I.T., Govt. of India.  
Former Director, Incharge & Professor, National Brain Research Centre, NBRC-Deemed University, DBT, GOI;  
Gurgaon (Delhi).

**3. Prof. M. Manivannan, IIT Madras**

Manivannan M [mani@iitm.ac.in](mailto:mani@iitm.ac.in) via [iitmandi.ac.in](mailto:iitmandi.ac.in)

Wed, Dec 19,  
2018, 8:49 PM

to Shubhajit

Nice Curriculum designed, congratulations.

Few minor suggestions:

V, VI semesters can have few specialization labs such as (a) Biomedical Instrumentation Lab, Biomechanics Lab,  
(b) Systems Biology Lab, Omics Lab, (c) Biosensors Lab, Nanotechnology lab.

Can you think of adding a biomaterials course.

Can you think of adding a ANalog and Digital Circuits course

Can you think of adding a modeling and simulation course

In summary, I am for master level programme alone, with various specialization as designed.

Hope this is useful.

-M Manivannan

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Dr.M.Manivannan  
Touch Lab  
Biomedical Engineering Group  
Department of Applied Mechanics  
IIT Madras - Chennai-36

<http://apm.iitm.ac.in/biomedical/mani>

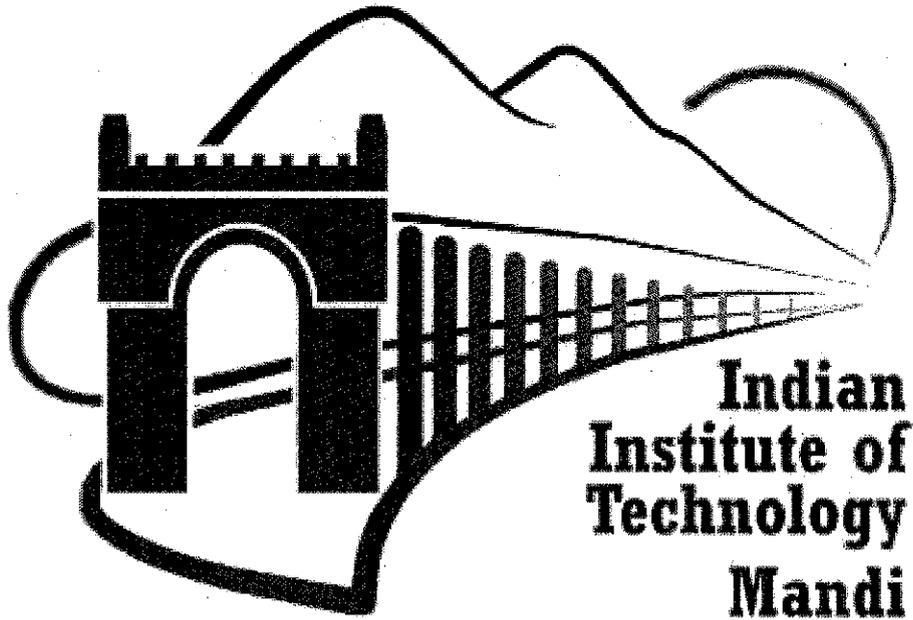
<http://apm.iitm.ac.in/biomedical/touchlab>

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# **Proposal for B. Tech. in Engineering Physics**



**School of Basic Sciences  
IIT Mandi**

**Preamble:**

Engineering Physics (EP) is a unique program which will provide a rigorous foundation in Physics along with a good background in Engineering disciplines. It will enhance the cross-functionality and bridge the gap between pure science and traditional engineering disciplines. This is necessary because in today's world major scientific and technological breakthroughs happen in a multi-disciplinary environment where scientists from pure science work along with engineers. It is, therefore, highly important to inculcate both scientific and technological aspects, and the EP programme will serve this purpose. A point to note is the fact that it has already been running successfully at IIT-M, IIT-B, IIT-G, IIT-D, etc.

The curriculum for EP at IIT Mandi introduces students to a wide variety of fields in pure as well as applied Physics. The core courses cover basic areas in Physics, such as Quantum Mechanics, Statistical Mechanics and Condensed Matter Physics; as well as basic courses in Mathematics and Engineering. In addition to the compulsory courses, students will complete a certain number of elective courses in Physics intended to provide a good exposure in various directions in both theoretical and applied Physics. The vision is to cater to and enhance the curiosity of students with varied interests in the field. Laboratory courses aim to cover the basic techniques used in different fields which would be an essential asset to every experimentalist. IIT Mandi has the necessary state-of-the-art labs to serve this purpose.

Besides, a number of courses in other branches of science and engineering, along with humanities and social sciences, will also be available as electives. This will allow students to explore their areas of interest. If a student is inclined towards electrical engineering, s/he can take the requisite number of courses/credits in that program and get a minor.

**Program Details:**

The B.Tech. in Engineering Physics will follow the same curriculum structure followed by the other B.Tech. degree programmes at IIT Mandi. The detailed curriculum, including theory and laboratory courses semester-wise, is described below:

<b>B.Tech. (Engineering Physics) - 1st Sem.</b>						
Sr.No.	Core/Elective	Course Name	Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
1	<b>IC-110</b>	<b>Engineering Mathematics</b>	2	1	0	3
2	<b>IC-152, 152P</b>	<b>Data Science (DS)-1 + Lab</b>	3	0	2	5
3	<b>IC-160, 160P</b>	<b>Electrical Systems Around Us + Lab</b>	3	0	2	5
4	<b>IC-140</b>	<b>Graphics for design</b>	3	0	1	4
5	<b>IC-110P</b>	<b>D&amp; IP – Understanding Products through Reverse Engineering</b>	0	0	0	2
6	<b>IC</b>	<b>HSS Course</b>	3	0	0	3
7	<b>IC</b>	<b>HSS - Creative understating</b>				1
<b>Summary</b>		<b>Total # Theory courses - 5</b>			<b>Total Credits</b>	<b>23</b>
		<b>Total No of Labs-3</b>				

**Completed Credits: 23**

**Remaining Credits: 137**



<b>B.Tech. (Engineering Physics) – 2<sup>nd</sup> Sem.</b>						
Sr.No.	Core/Elective	Course Name	Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
1	IC-111	Linear Algebra	3	0	0	3
2	IC-252	Data Science (DS)-2 Probability, Statistics and Random Processes	3	0	0	3
3	IC-161, 161P	Applied Electronics + Lab	3	0	2	5
4	IC-142	Engineering Thermodynamics	3	0	1	4
5	IC-141, IC141P	Product Realization Technology + Lab	2	0	2	4
6	IC	HSS Course	3	0	0	3
<b>Summary</b>		<b>Total # Theory courses - 6</b>			<b>Total Credits</b>	<b>22</b>
		<b>Total No of Labs-2</b>				

**Completed Credits: 23+22=45**

**Remaining Credits: 115**

<b>B.Tech. (Engineering Physics) – 3<sup>rd</sup> Sem.</b>						
Sr.No.	Core/Elective	Course Name	Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
1	IC-121	Mechanics of particles and waves	3	0	0	3
2	IC-130	Applied Chemistry for Engineers	3	0	0	3
3	IC-130P	Chemistry Practicum	0	0	3	2
4	C-1, EP3XX	Engineering Mathematics-2	3	0	0	3
5	IC-352 (CS202+I C250)	<u>Data Science (DS)-3, (Data Structure and Algorithm)</u>	3	0	0	3
6	IC-240	Mechanics of Rigid Bodies	3	0	0	3
7	IC	HSS Course	3	0	0	3
Summary		Total # Theory courses - 6			Total Credits	20
		Total No of Labs-1				

Completed Credits:  $23+22+20=65$

Remaining Credits: 95

<b>B.Tech. (Engineering Physics) – 4<sup>rd</sup> Sem.</b>						
Sr.No.	Core/Elective	Course Name	Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
1	IC-221	Foundation of electrodynamics	3	0	0	3
2	IC-222P	Physics Practicum	0	0	3	2
3	IC-221	Signals and systems	3	0	0	3
4	IC-241	Materials Science for Engineers	3	0	0	3
5	IC-242	Continuum Mechanics	3	0	0	3
6	IC-201P	Design Practicum	0	0	6	4
7	IC-136	Understanding Biotechnology & Its Applications	3	0	0	3
<b>Summary</b>		<b>Total # Theory courses - 5</b>			<b>Total Credits</b>	<b>21</b>
		<b>Total No of Labs-2</b>				

**Completed Credits:  $23+22+20+21=86$**

**Remaining Credits: 74**

<b>B.Tech. (Engineering Physics) – 5<sup>th</sup> Sem.</b>						
Sr.No.	Core/Elective	Course Name	Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
1	<b>C-2, PH301</b>	<b>Quantum Mechanics and Applications</b>	3	0	0	3
2	<b>C-3, EE311</b>	<b>Device Electronics for Integrated Circuits</b>	3	0	0	3
3	<b>C-4, EP3XX</b>	<b>Computational Methods for Engineering</b>	3	0	2	4
4	<b>DE-1</b>	<b>Discipline Elect.- 1</b>	3	0	0	3
5	<b>DE-2</b>	<b>Discipline Elect.-2</b>	3	0	0	3
6	<b>IC</b>	<b>HSS Course</b>	3	0	0	3
<b>Summary</b>		<b>Total # Theory courses - 6</b>			<b>Total Credits</b>	<b>19</b>
		<b>Total No of Labs-0</b>				

**Completed Credits: 23+22+20+21+19=105**

**Remaining Credits: 55**

<b>B.Tech. (Engineering Physics) – 6<sup>th</sup> Sem.</b>						
Sr.No.	Core/Elective	Course Name	Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
1	C-5, PH302	Introduction to Statistical Mechanics	3	0	0	3
2	C-6, PH501	Solid State Physics	3	0	0	3
3	C-7, EP4XXP	Engineering of Instrumentation	1	0	3	4
4	C8-PH502	Photonics	3	0	0	3
5	E	Open/Free Elective	3	0	0	3
6	DP301P(E)	ISTP				4
<b>Summary</b>		<b>Total # Theory courses - 6</b>			<b>Total Credits</b>	<b>20</b>
		<b>Total No of Labs-0</b>				

**Completed Credits: 23+22+20+21+19+20=125**

**Remaining Credits: 35**

<b>B.Tech. (Engineering Physics) – 7<sup>th</sup> Sem.</b>						
Sr.No.	Core/Elective	Course Name	Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
1	C-9,EP4XXP	Eng. Physics Practicum	1	0	3	4
2	DE-3	Discipline Elective	3	0	0	3
3	DP401P(E)	MTP-I	0	0	0	3
4	E	Open/Free Electives (2 No.)	-	-	-	6
<b>Summary</b>		Total # Theory courses - 4			<b>Total Credits</b>	<b>16</b>
		Total No of Labs-1				

**Completed Credits: 23+22+20+21+19+20+16=141**

**Remaining Credits: 19**

<b>B.Tech. (Engineering Physics) – 8<sup>th</sup> Sem.</b>						
Sr.No.	Core/Elective	Course Name	Lecture (L)	Tutorial (T)	Practical (P)	Credit (C)
1	DE-4	Disci. Elective	3	0	0	3
2	DP401P(E)	MTP-II	-	-	-	5
3	E	Open/Free Electives (3 no.)	-	-	-	9
4						
<b>Summary</b>		Total # Theory courses - 3			<b>Total Credits</b>	<b>17</b>
		Total No of Labs-0				

**Completed Credits: 23+22+20+21+19+20+16+17=158**

**Internship: 2**

**Total credits completed: 158+2 (internship) = 160**

**Credits distribution over the four-year program**

Semester /Courses	1 <sup>st</sup> #course s(credit s)	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	6 <sup>th</sup>	7 <sup>th</sup>	8 <sup>th</sup>	Total #courses (credit)
IC	7(23)	8(22)	6(17)	7(21)	1(3)	-	-	-	29(86)
Core (Discipline)	-	-	1(3)	-	3(10)	4(13)	1(4)	-	10(30)
Electives (Discipline)	-	-	-	-	2(6)	-	1(3)	1(3)	4(12)
Free/Open electives	-	-	-	-	-	2(7) (3+ ISTP)	3(9) (6+ MTPI)	4(14) (9+ MTPII)	9(30)

**Total credits: 158**

**Internship: 2  
Grand Total: 160**

**Proposed Intake for the program B.Tech. in Engineering Physics, Aug. 2019:**

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### Engineering Physics Discipline Core Courses Details

	CORE COURSES	L	T	P	C	Semester
C-1	Engineering Mathematics-2 (EP3XX)	3	0	0	3	3
C-2	Quantum Mechanics and Applications (PH301)	3	0	0	3	5
C-3	Device Electronics for Integrated Circuits (EE311)	3	0	0	3	5
C-4	Computational Methods for Engineering (EP3XX)	3	0	2	4	5
C-5	Introduction to Statistical Mechanics (PH302)	3	0	0	3	6
C-6	Solid State Physics (PH501)	3	0	0	3	6
C-7	Engineering of Instrumentation (EP4XXP)	2	0	3	4	6
C-8	Photonics (PH502)	3	0	0	3	6
C-9	Eng. Physics Practicum (EP4XXP)	2	0	3	4	7
	<b>TOTAL CREDITS</b>				<b>30</b>	



Discipline core courses structure has been decided from a core body of knowledge/concept skills. Based on the required core knowledge, which is essential for a student enrolled in this program, broadly we have divided into following baskets. A tentative list of courses under each basket is given below.

<b>A. Laser/Photonics/optics</b>	<b>B. Quantum Devices/Devices</b>
1. Quantum Mechanics and Application (PH301) 2. Engineering Mathematics-2 (EP3XX) 3. Introduction to Statistical Mechanics (PH302) 4. Solid State Physics (PH501) 5. Photonics (PH502) 6. Quantum computation and information (PH5XX) 7. Atomic and Molecular Physics (PH524) 8. Quantum Optics (PH6XX) 9. Laser and Applications (PH503) 10. Mesoscopic Physics and Quantum Transport (PH601) 11. Quantum Devices (PH6XX) 12. Special Topics in Quantum Mechanics (PH613) 13. Advanced Communication Theory (EE503) 14. Optical communication systems (EE614)	1. Quantum Mechanics and Application (PH301) 2. Engineering Mathematics-2 (EP311) 3. Photonics (PH502) 4. Introduction to Statistical Mechanics (PH302) 5. Automata Theory (CS304) 6. Mathematical Foundations of CS (CS208) 7. Quantum Optics (PH6XX) 8. Device Electronics for Integrated Circuits (EE311) 9. Eng. Physics Practicum (PH4XX) 10. Computational Methods for Engineering (EP3XX) 11. Solid State Physics (PH501) 12. Quantum Devices (PH6XX) 13. VLSI Technology ( EE-611) 14. Information Theory (EE-518) 15. Introduction to Cryptography (CS 241) 16. Microwave Integrated circuits (EE 622) 17. Power Semiconductor Devices (EE )
<b>C. Instrumentation</b>	<b>D. Physics Research and Teaching</b>
1. Eng. Physics Practicum (PH4XXP) 2. Computational Methods for Engineering (PH3XX) 3. Microelectronics Devices and Modelling (EE-520) 4. Nano Electronics and Nano – Microfabrication (EE-615)	1. Engineering Mathematics-2 (EP3XX)/Mathematical Physics (PH511) 2. Classical Mechanics (PH512) 3. Quantum Mechanics and Application (PH301)/Quantum Mechanics (PH513) 4. Electromagnetic Theory (PH521)

5. Nanomanufacturing (ME509)	5. Introduction to Statistical Mechanics (PH302)/ Statistical Mechanics (PH522)
6. Experimental Research Techniques (PH611)	6. Solid State Physics (PH501)/Condensed Matter Physics (PH523)
7. Energy Conversion Devices (ME307)	7. Atomic and Molecular Physics (PH524)
8. Applied Computational Fluid Dynamics (ME615)	8. Nuclear and Particle Physics (PH612)
9. Microelectronics Circuits Design Practicum ( EE 312 P)	9. Special topics in Quantum Mechanics (PH613)
10. Control System Applications (EE602)	10. Laser and Applications (503)
11. Electromechanics/Lab ( EE 201/201P)	11. Organic Optoelectronics (504)
12. VLSI Technology/Lab ( EE-611/611P)	12. X-ray as a probe to study the material properties (507)
13. Radiating Systems (EE621)	13. Magnetism and Magnetic Materials (PH508)
14. Engineering of Instrumentation (EP4XXP)	14. Mesoscopic Physics and Quantum Transport (PH601)
15. Control Systems Engineering (EE 301)	15. Advanced Condensed Matter Physics (PH603)

- List of Courses, as decided by the CIG, from Physics, Mathematics, Electrical, Mechanical and Computer Science are included in the Discipline Electives. Tentative list of elective courses from Physics are listed below.

Sr.No.	Code	Course Name
1.	PH503	Laser and Applications
2.	PH503	Organic Optoelectronics
3.	PH507	X-ray as a probe to study the material properties
4.	PH508	Magnetism and Magnetic Materials
5.	PH601	Mesoscopic Physics and Quantum Transport
6.	PH603	Advanced Condensed Matter Physics
7.	PH612	Nuclear and Particle Physics
8.	PH524	Atomic and Molecular Physics
9.	PH613	Special Topics in Quantum Mechanics



**List of courses for B.Tech. in Engineering Physics**

Sr. No.	Course Code	Course Name	Credits
1	IC-110	Engineering Mathematics	3
2	IC-152	Data Science (DS)-I (Computation for engineers)	3
3	IC-152P	DS-I -Lab	2
4	IC-160	Electrical Systems Around Us	3
5	IC-160	Electrical Systems Around Us -Lab	2
6	IC-140	Graphics for design	4
7	IC-110P	Reverse Engineering (Lab)	2
8	IC-111	Linear Algebra	3
9	IC-252	Data Science-2	3
10	IC-161	Applied Electronics	3
11	IC-161P	Applied Electronics-Lab	2
12	IC-142	Engineering Thermodynamics	3
13	IC-141	Product Realization Technology	2
14	IC-141P	Product Realization Technology-Lab	2
15	IC-121	Mechanics of particles and waves	3
16	IC-130	Applied Chemistry for Engineers	3
17	IC-130P	Applied Chemistry for Engineers-Lab	2
18	IC-352	Data Science (DS)-3	3
19	IC-240	Mechanics of rigid bodies	3
20	IC-221	Foundation of electrodynamics	3
21	IC-222P	Physics Practicum	2
22	IC-221	Signals and Systems	3
23	IC-241	Materials science for engineers	3
24	IC-242	Continuum Mechanics	3

25	IC-201P	Design Practicum	4
26	IC-136	Understanding biotechnology and its applications	3
27	DP301P	Interdisciplinary Socio-Technical Practicum	4
28	DP401P	Major Technical Project	8
29	EP-3XX	Engineering Mathematice-2	3
30	EE-311	Device Electronics for Integrated Circuits	3
31	PH-301	Quantum Mechanics and Applications	3
32	EP3XX	Computational Methods for Engineering	4
33	PH-302	Introduction to Statistical Mechanics	3
34	PH-501	Solid State Physics	3
35	EP-4XXP	Eng. Of Instrumentation	4
36	EP-4XXP	Eng. Phys. Practicum	4
37	PH-612	Nuclear and Particle Physics	3

**List of courses, semester wise, already approved by the senate is given below:**

**Semester 1:**

<b>S.No.</b>	<b>Core/ Elective</b>	<b>Course Name</b>
1	IC-110	Engineering Mathematics
2	IC- 152,152P	Data Science(DS)-1 Computation for Engineers + Lab
3	IC-160	Electrical Systems Around Us + Lab
4	IC-140	Graphics for design
5	IC-110P	D& IP – Understanding Products through Reverse Engineering (Lab)
6	IC	HSS Course
7	IC	HSS - Creative understating

**Semester 2:**

<b>S.No.</b>	<b>Core/ Elective</b>	<b>Course Name</b>
1	IC-111	Linear Algebra
2	IC-252	Data Science(DS)-2 Probability, Statistics and Random Processes
3	IC-161,161P	Applied Electronics + Lab
4	IC-142	Engineering Thermodynamics
5	IC-141	Product Realization Technology
6	IC-141P	Product Realization Technology Lab

7	IC	HSS Course
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**Semester 3:**

S.No.	Core/ Elective	Course Name
1	IC-121	Mechanics of particles and waves
2	IC-130,130P	Applied Chemistry for Engineers + Lab
3	IC-352 (CS202+IC250)	Data Science-3, (Data Structure and Algorithm)
4	IC-240	Mechanics of Rigid Bodies
5	IC	HSS Course

**Semester 4:**

S. No.	Core/ Elective	Course Name
1.	IC-221	Foundation of electrodynamics
2.	IC-222P	Physics Practicum
3.	IC-221	Signals and systems
4.	IC-241	Materials Science for Engineers
5.	IC-242	Continuum Mechanics
6.	IC-201P	Design Practicum

7.	IC-136	Understanding Biotechnology & Its Applications
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**Semester 5:**

S.No.	Core/ Elective	Course Name
1	C-3, PH301	Quantum Mechanics and applications
2	C-4, EE311	Device Electronics for Integrated Circuits

**Semester 6:**

S.No.	Core/ Elective	Course Name
1.	C-5, PH302	Introduction to Statistical Mechanics
2.	C-6, PH501	Solid State Physics
3.	C-8, PH502	Photonics
4.	E, DP301P	ISTP

**Semester 7:**

S.No.	Core/ Elective	Course Name
1.	DE-3, PH612	Nuclear and Particle Physics
2.	E, DP401P	MTP-A

**Semester 8:**

S.No.	Core/ Elective	Course Name
1.	E, DP401P	MTP-B