**Course of Study**

**(Under CBCS scheme)**

# B. Tech. (Information Technology & Mathematical Innovations)

**Scheme of study and examination**

**(20xx onwards)**

## CLUSTER INNOVATION CENTRE
## UNIVERSITY OF DELHI

## INDEX

### Content: B.Tech. (IT & Mathematical Innovations)

# B. Tech. (IT & Mathematical Innovations)

## *Preamble*

### INTRODUCTION

This unique course, the first one to be offered at Cluster Innovation Centre, is designed to inculcate an innovation mindset as part of the curriculum and pedagogy. Building strong analytical skills through Mathematics and application skills of Information Technology (IT), this course encourages students to recognize the connectedness of various disciplines. Using IT as a vehicle for connecting mathematics with other disciplines, students are encouraged to develop innovative products and processes as part of curriculum. The course aims to produce adequately skilled graduates with a creative mindset who can provide new solutions to industry in particular and to society in general. It is hoped that some of these innovators will be entrepreneurs, who will be job providers rather than job seekers. The course is specifically designed to boost undergraduate research.

The course offers three discipline centric elective streams – Management, Electronics & Embedded System and Systems Biology – important fields of education with significant interface with Mathematics and IT. The mode of learning shall be a healthy and productive blend of the formal and the inquiry based, with special focus on "hands on" and "project based" mode of learning. Learning shall happen to a large extent through teacher mentoring and peer learning that encourages creativity and relies on innovations. This is in tandem with the requirement of CBCS tenets.

Upon graduation, these students would have acquired innovation based creativity and would have matured in their thinking. They will have enhanced their communication and leadership abilities, and will have understood the deep and abiding connections between knowledge and its uses - between understanding the needs of society and the relevance of knowledge and the importance of societal obligations. Experiments, hands-on projects, innovative projects, model implementations linked to the curriculum will be carried out in the "Engineering Kitchen: Innovation Lab". Assessment, at each stage, is designed in a manner to incentivize innovation by encouraging students to carry out new creative application of the theoretical knowledge acquired, either through a project, or through a laboratory activity/prototype in the engineering kitchen.

### CHOICE BASED CREDIT SYSTEM (CBCS)

The credit based semester system provides flexibility in designing curriculum and assigning credits based on the course content and hours of teaching. The Choice Based Credit System provides a 'cafeteria' type approach in which the students can take courses of their choice, learn at their own pace, undergo additional courses to acquire more than the required credits and adopt an interdisciplinary approach to learning.

### PROGRAMME OBJECTIVES

**PO1**: To inculcate an innovation mindset as part of the curriculum and pedagogy. Building strong analytical skills through Mathematics and application skills of Information Technology (IT).

**PO2**: To create an interdisciplinary learning approach.

**PO3**: To promote learning based on "hands-on" and "project-based" mode of learning.

**PO4**: To aim to produce adequately skilled graduates with a creative mindset who can provide new solutions to industry in particular and to society in general.

**PO5**: To encourage students under mentoring of teachers, for innovation and entrepreneurship. In addition to this, the course is specifically designed to boost undergraduate research.

**TYPE OF COURSES**

The courses (or the subjects) to be taught in this program are categorized into three types:

i. **Core Course (CC):** This is a course that is to be compulsorily studied by a student as a core requirement to complete the requirement of B.Tech (IT and Mathematical Innovations).

ii. **Elective Course:** An elective course is a course that can be chosen from a pool of courses. It is intended to support the discipline of study by providing an expanded scope, enabling exposure to another discipline/domain and nurturing a student's proficiency and skill. An elective may be of following types:

a) **Discipline Centric Elective (DCE)**: It is an elective course that adds proficiency to the students in the discipline or leads to an interdisciplinary approach to learning.

b) **Open Elective (OE):** It is an elective course offered by different academic disciplines at CIC that broadens the perspective of a student undergoing the B.Tech course.

iii. **Foundation Course (FC):** A Foundation course leads to knowledge enhancement and provides value-based training.

A student shall accumulate 50% of the credits from Core Courses, 25% credits from Foundation Courses and the rest from elective courses.

**NO OF SEATS:** 40

**DURATION:** 8 Semesters (4 years)

**ELIGIBILITY:** A minimum aggregate marks at 10+2 level as follows

General Category : 60 % in four subjects (including mathematics)
OBC category : 54% in four subjects (including mathematics)
PH category : 55% in four subjects (including Mathematics)
SC/ST category : Passing marks with Mathematics as one subject

**ADMISSION:** Through a written MCQ based entrance test.

**COURSE FEE:** As notified by the university time to time

## B. Tech. (IT & Mathematical Innovations)

### COURSE STRUCTURE

**Key: L: Lecture, T: Tutorial, P: Project/Practical/Internship,**
**IA: Internal Assessment, EA: External Assessment (End semester exams)**

## Semester I

| Paper No. | Interactive Learning Modules (Paper Title) | Credits | | | | Marks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Theory | | Practical | | Total |
| | | L | T | P | Total | IA | EA | IA | EA | |
| I.1 (FC) | Seeing the world through ***Calculus***. First steps through symbolic mathematics | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| I.2 (FC) | Modeling continuous changes through ***ordinary differential equations*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| I.3 (FC) | Automating real world through Programs: ***Programming Fundamentals*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| I.4 (FC) | Understanding ***Computing Systems Architecture*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| I.5 (FC) | Physics at work I: ***Deconstructing Machines*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| I.6 (FC) | ***Business, Entrepreneurship and Innovation Management*** | 2 | 0 | 0 | 2 | 20 | 30 | 0 | 0 | 50 |
| I.7 (FC) | ***Environment Science & Ecosystem Management*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| **Grand Total** | | | | | **26** | | | | | 650 |

**Key: L: Lecture, T: Tutorial, P: Project/Practical/Internship,**
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## Semester II

| Paper No. | Interactive Learning Modules (Paper Title) | Credits | | | | Marks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | Total | Theory | | Practical | | Total |
| | | | | | | IA | EA | IA | EA | |
| II.1 (FC) | Linearity in Nature: Engineering through ***Linear Algebra***. First steps through numerical algorithms | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| II.2 (FC) | Understanding real life situations through ***Discrete Mathematics*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| II.3 (FC) | Optimizing memory use through ***Data Structure and Design*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| II.4 (FC) | Reflecting thought processes via ***Object Oriented Programming*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| II.5 (FC) | Physics at work II: ***Deconstructing devices*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| II.6 | **Open Elective - 1** | | | | | | | | | |
| II.7 | **Knowing specialization streams (Foundation Course Electives (FC))** | | | | | | | | | |
| II.7.1 | ***Business processes and strategic IT alignment*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| II.7.2 | ***Electronics at work & circuit simulations*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| II.7.3 | ***Exploring Biology - Systems Approach*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| | **Grand Total** | | | | **26 / 28** | | | | | 650 / 700 |

**Note:**

1. The student may opt for only one paper in II.6 from the set of open electives for even semester (Table 2).

2. The student may opt for one or more papers in II.7. Only one paper will be included in the transcript as credit paper and the others as non-credit paper.

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## Semester III

| Paper No. | Interactive Learning Modules (Paper Title) | Credits | | | | Marks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | Total | Theory | | Practical | | Total |
| | | | | | | IA | EA | IA | EA | |
| III.1 (CC) | Modeling change in the world around us: ***Partial Differential Equations*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| III.2 (CC) | ***Design and Analysis of Algorithms*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| III.3 (CC) | Handling Information through ***Data Modeling and Design*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| III.4 | **Open Elective – 2 (OE)** | | | | | | | | | |
| III.5 | **Discipline Centric Elective – 1 (DCE)** | | | | | | | | | |
| III.5.1 | Understanding ***Economic Behavior***: The ***micro*** level | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| III.5.2 | ***Electronics circuit elements and instruments*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| III.5.3 | ***Integrative Biology*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| III.6 | **Discipline Centric Elective – 2 (DCE)** | | | | | | | | | |
| III.6.1 | ***Principles of Management*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| III.6.2 | ***Electronics circuit elements and instruments – Innovation Lab*** | 0 | 0 | 4 | 2 | 0 | 0 | 25 | 25 | 50 |
| III.6.3 | ***Cell: Biochemical and Molecular perspective*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| III.7 (CC) | Summer Internship: projects drawn from the world around us | 0 | 0 | 8 | 4 | 0 | 0 | 40 | 60 | 100 |
| | **Grand Total** | | | | **24 / 26** | | | | | 600 / 650 |

**Note:**

1. The student may opt for only one paper in III.4 from the set of open electives for odd semester (Table 1).
2. The students will opt for only one elective in III.5 & III.6.
3. The student will execute the internship III.7 during the preceding summer break.

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## Semester IV

| Paper No. | Interactive Learning Modules (Paper Title) | Credits | | | | Marks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | Total | Theory | | Practical | | Total |
| | | | | | | IA | EA | IA | EA | |
| IV.1 (CC) | Does Nature play dice?: The amazing world of ***probability and statistics*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| IV.2 (CC) | Instructing computing devices: ***Operating System*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| IV.3 (CC) | Information exchange in computing devices: ***Data Communication & Networking*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| IV.4 | **Open Elective – 3 (OE)** | | | | | | | | | |
| IV.5 | **Discipline Centric Elective – 3 (DCE)** | | | | | | | | | |
| IV.5.1 | Understanding ***Economic Behaviour***: The ***macro*** level | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| IV.5.2 | ***Digital electronics and logic design*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| IV.5.3 | ***In silico Biology*** | 2 | 0 | 4 | 4 | 15 | 35 | 25 | 25 | 100 |
| IV.6 | **Discipline Centric Elective – 4 (DCE)** | | | | | | | | | |
| IV.6.1 | Bringing Companies and clients together: **Sales & Marketing management** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| IV.6.2 | ***Digital electronics and logic design*** – Innovation Lab | 0 | 0 | 4 | 2 | 0 | 0 | 25 | 25 | 50 |
| IV.6.3 | ***Flow of information in living systems*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| IV.7 (CC) | Semester long innovation project | 0 | 0 | 8 | 4 | 0 | 0 | 40 | 60 | 100 |
| | **Grand Total** | | | | **24 / 26** | | | | | 600 / 650 |

**Note:**

1. The student may opt for only one paper in IV.4 from the set of open electives for even semester (Table 2).
2. The student will attend only one elective in IV.5 & IV.6.
3. The student will finalize the semester long project title, area, and mentor(s) for IV.7 during Semester III. The project work will commence from the beginning of the preceding winter break.

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## Semester V

| Paper No. | Interactive Learning Modules (Paper Title) | Credits | | | | Marks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | Total | Theory | | Practical | | Total |
| | | | | | | IA | EA | IA | EA | |
| V.1 (CC) | Complexity and Symmetry in Mathematics: ***Complex Analysis and Algebra*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| V.2 (CC) | ***Computer Graphics and Visualization*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| V.3 (CC) | Computer and Brain: Knowledge Discovery and ***Artificial Intelligence*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| V.4 | **Open Elective – 4 (OE)** | | | | | | | | | |
| V.5 | **Discipline Centric Elective – 5 (DCE)** | | | | | | | | | |
| V.5.1 | Maximizing performance: ***Human Resource management and Organizational Behavior*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| V.5.2 | ***Embedded systems studio - I*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| V.5.3 | ***Applied Genomics and Proteomics*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| V.6 | **Discipline Centric Elective – 6 (DCE)** | | | | | | | | | |
| V.6.1 | Efficient manufacturing process: ***Production and Operations Management*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| V.6.2 | ***Signals & Systems Engineering*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| V.6.3 | Biological Instrumentation Kitchen: ***Genomics and Proteomics*** | 0 | 0 | 8 | 4 | 0 | 0 | 40 | 60 | 100 |
| V.7 (CC) | Industrial mini project | 0 | 0 | 8 | 4 | 0 | 0 | 40 | 60 | 100 |
| | **Grand Total** | | | | **26 / 28** | | | | | 650 / 700 |

**Note:**

1. The student may opt for only one paper in V.4 from the set of open electives for odd semester (Table 1).
2. The students will opt for only one elective in V.5 & V.6.
3. The student will execute the industrial mini project V.7 during the preceding summer break.

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## Semester VI

| Paper No. | Interactive Learning Modules (Paper Title) | Credits | | | | Marks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | Total | Theory | | Practical | | Total |
| | | | | | | IA | EA | IA | EA | |
| VI.1 (CC) | Linear Construction of Actions: Engineering through ***Linear Programming and Game Theory*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| VI.2 (CC) | Decoding Computation Structure and ***Logic*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| VI.3 (CC) | ***Internet and Web Technology*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| VI.4 | **Open Elective – 5 (OE)** | | | | | | | | | |
| VI.5 | **Discipline Centric Elective – 7 (DCE)** | | | | | | | | | |
| VI.5.1 | Handling money: ***Finance management*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| VI.5.2 | ***Embedded systems studio – II*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| VI.5.3 | ***Biological Networks***: from Micro to Macro niche | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| VI.6 | **Discipline Centric Elective – 8 (DCE)** | | | | | | | | | |
| VI.6.1 | ***e - Business***: Organization and Strategy | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| VI.6.2 | ***Control systems*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| VI.6.3 | ***Genes to Genomes*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| VI.7 (CC) | Project in Industry, Society and Villages | 0 | 0 | 8 | 4 | 0 | 0 | 40 | 60 | 100 |
| | **Grand Total** | | | | **26 / 28** | | | | | 650 / 700 |

**Note:**

1. The student may opt for only one paper in VI.4 from the set of open electives for even semester (Table 2).
2. The student will attend only one elective in VI.5 & VI.6.
3. The student will finalize the semester long project title, area, and mentor(s) for VI.7 during Semester V. The project work will commence from the beginning of the preceding winter break.

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## Semester VII

| Paper No. | Interactive Learning Modules (Paper Title) | Credits | | | | Marks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | Total | Theory | | Practical | | Total |
| | | | | | | IA | EA | IA | EA | |
| VII.1 (CC) | Algorithms for Computational Mathematics: ***Numerical Methods*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| VII.2 (CC) | ***Software Engineering and Project Management*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| **VII.3** | **Discipline Centric Elective – 9 (DCE)** | | | | | | | | | |
| VII.3.1 | ***Computer Language Design & Engineering*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| VII.3.2 | Making Society Smart through ***Computational Social Systems*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| VII.3.3 | Introduction to ***Natural Language Processing*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| VII.4 | **Open Elective – 6 (OE)** | | | | | | | | | |
| VII.5 | **Discipline Centric Elective – 10 (DCE)** | | | | | | | | | |
| VII.5.1 | ***Environment Management*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| VII.5.2 | Engineering at Molecular Scale: ***Devices and Nanotechnology*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| VII.5.3 | ***Biodefense and Bioengineering*** | 3 | 1 | 0 | 4 | 50 | 50 | 0 | 0 | 100 |
| VII.6 | **Discipline Centric Elective – 11 (DCE)** | | | | | | | | | |
| VII.6.1 | ***Business automation strategies***. ERP. Case studies and project in industry | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| VII.6.2 | ***Circuit Analysis and Synthesis*** | 3 | 0 | 2 | 4 | 30 | 40 | 15 | 15 | 100 |
| VII.6.3 | ***Systems Biology*** | 2 | 0 | 4 | 4 | 15 | 35 | 25 | 25 | 100 |
| VII.7 (CC) | Industrial mini project, Simulation of real time cases | 0 | 0 | 8 | 4 | 0 | 0 | 40 | 60 | 100 |
| | **Grand Total** | | | | **26 / 28** | | | | | 650 / 700 |

**Note:**

1. The student may opt for only one paper in VII.4 from the set of open electives for odd semester (Table 1).
2. The students will opt for only one elective in VII.3, VII.5 & VII.6.
3. The student will execute the industrial mini project VII.7 during the preceding summer break.

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## Semester VIII

| Paper No. | Interactive Learning Modules (Paper Title) | Credits | | | | Marks | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | Total | Theory | | Practical | | Total |
| | | | | | | IA | EA | IA | EA | |
| VIII.1 (CC) | Industrial Internship/Major Project | 0 | 0 | 52 | 26 | 0 | 0 | 300 | 350 | 650 |
| **Grand Total** | | 0 | 0 | 52 | **26** | 0 | 0 | 300 | 350 | 650 |

**Note:**

1. Students will decide the field of work and the organization for execution of the Industrial Internship/Major Project VIII.1 during Semester VII.
2. The Industrial Internship/ Major Project VIII.1 will be of minimum 20 weeks duration.

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### OPEN ELECTIVES

Table 1: Open Electives (Odd Semester)

| Interactive Learning Modules (Paper Title) | Credits | | | | Marks | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | L | T | P | Total | Theory | | Practical | | Total |
| | | | | | IA | EA | IA | EA | |
| Language and Communication: ***Computational Linguistics*** | 2 | 0 | 0 | 2 | 25 | 25 | 0 | 0 | 50 |
| ***History, culture & civilization*** | 2 | 0 | 0 | 2 | 25 | 25 | 0 | 0 | 50 |
| ***Visual arts & aesthetics*** | 2 | 0 | 0 | 2 | 25 | 25 | 0 | 0 | 50 |
| ***An introduction to GIS and GPS**** | 4 | 0 | 0 | 4 | 40 | 60 | 0 | 0 | 100 |
| ***Computer Applications in Humanities & Social Science Research**** | 4 | 0 | 0 | 4 | 40 | 60 | 0 | 0 | 100 |
| ***Appreciating Literary Works**** | 4 | 0 | 0 | 4 | 40 | 60 | 0 | 0 | 100 |
| ***Introduction to Documentary – Technologies & Techniques**** | 4 | 0 | 0 | 4 | 40 | 60 | 0 | 0 | 100 |
| ***Education Entrepreneurship for Social Change***** | 2 | 0 | 0 | 2 | 12 | 38 | 0 | 0 | 50 |
| ***Education for Sustainable Future***** | 2 | 0 | 0 | 2 | 12 | 38 | 0 | 0 | 50 |

Table 2: Open Electives (Even Semester)

| Interactive Learning Modules (Paper Title) | Credits | | | | Marks | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | L | T | P | Total | Theory | | Practical | | Total |
| | | | | | IA | EA | IA | EA | |
| Art of ***Communication & Creative Writing*** | 2 | 0 | 0 | 2 | 25 | 25 | 0 | 0 | 50 |
| ***Science, Philosophy, Truth: Impact of technology*** | 2 | 0 | 0 | 2 | 25 | 25 | 0 | 0 | 50 |
| ***Art & Design*** | 2 | 0 | 0 | 2 | 25 | 25 | 0 | 0 | 50 |
| ***Legal Literacy**** | 4 | 0 | 0 | 4 | 40 | 60 | 0 | 0 | 100 |
| ***Documentary Film making**** | 4 | 0 | 0 | 4 | 40 | 60 | 0 | 0 | 100 |
| ***Film Appreciation**** | 4 | 0 | 0 | 4 | 40 | 60 | 0 | 0 | 100 |
| ***Translation**** | 4 | 0 | 0 | 4 | 40 | 60 | 0 | 0 | 100 |
| ***Innovation in Education***** | 2 | 0 | 0 | 2 | 12 | 38 | 0 | 0 | 50 |
| ***Mathematical Visualizations***** | 2 | 0 | 0 | 2 | 12 | 38 | 0 | 0 | 50 |

- * Elective courses floated for BA Hons (Humanities and Social Sciences). The syllabus and evaluation of these courses will be as prescribed in the course structure and evaluation process of BA Hons (Humanities and Social Science)
- ** Elective courses floated for M.Sc (Mathematics Education). The syllabus and evaluation of these courses will be as prescribed in the course structure and evaluation process of M.Sc (Mathematics Education)

## B. Tech. (IT & Mathematical Innovations)

### EVALUATION SCHEME

There will be continuous assessment based on class tests, presentations, seminars, assignments, projects etc. There will be an **Evaluation and Review Committee (ERC)** for each Semester. The Programme Coordinator will be the Chairman of the ERC and all CONVENERS (teachers teaching major portions of a paper) concerned for the semester will be its members.

### FUNCTIONS OF THE ERC

a. To finalize examination schedule, its notification, preparation of invigilation chart and conduct of end semester examinations.
b. To ensure timely preparation of question papers and Evaluation of answer books for the end semester examination. ERC may assign full or a part of the work to any other faculty member of CIC.
c. To periodically assess the continuous evaluation of the papers and project/internship.
d. To determine and notify the eligibility of appearing in the end semester examination based on the attendance percentage prior to the commencement of the end semester examination.
e. To ensure timely notification of internal assessment marks. To consider such individual representations of students about internal evaluation which have not been possible to reconcile between the student and the concerned teacher and take the remedial action if needed. The case will be scrutinized by the ERC and the decision of the ERC shall be final.
f. To prepare the consolidated results semester wise and send them to the University Examination Branch for declaration of results.

### EVALUATION

a. Letter Grades and Grade Points: A 10-point grading system shall be used with the letter grades as given in Table 3.

**Table 3: Grades and Grade Points**

| Letter Grade | Grade Point |
|---|---|
| O (Outstanding) | 10 |
| $A^+$ (Excellent) | 9 |
| A (Very Good) | 8 |
| $B^+$ (Good) | 7 |
| B (Above average) | 6 |
| C (Average) | 5 |
| P (Pass) | 4 |
| F (Fail) | 0 |
| Ab (Absent) | 0 |

b. Computation of SGPA and CGPA: The following procedure shall be used to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

i. The SGPA is the ratio of sum of the product of the number of credits and the grade points scored in all the courses of a semester, to the sum of the number of credits of all the courses taken by a student, i.e.

$$SGPA\ (S_i) = \frac{\sum C_j \times G_j}{\sum C_j}$$

where $S_i$ is the $i^{th}$ Semester, $C_j$ is the number of credits of the $j^{th}$ course in that semester and $G_j$ is the grade point scored by the student in the $j^{th}$ course.

ii. The CGPA is also calculated in the same manner taking into account all the courses taken by a student over all the semesters of a programme, i.e.

$$CGPA = \frac{\sum C_i \times SGPA\ (S_i)}{\sum C_i}$$

where $SPGA\ (S_i)$ is the SGPA of the $i^{th}$ semester and $C_i$ is the total number of credits in that semester.

iii. The SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.

iv. CGPA shall be converted into percentage of marks if required, by multiplying CGPA with 10.

c. For a 4 credits paper of FC, CC and DCE with practical (3-0-2 or 2-0-4), the end semester assessment (EA) for practical will have a project. For a 4 credits paper of FC, CC and DCE with tutorial (3-1-0), the internal assessment (IA) of theory will have a project of 25% weightage. A practical paper of FC, CC and DCE with 4 credits, will have a project of minimum 30% weightage (Table 4). These projects must relate the application of theory to real world problem. However, the projects must be such that a student spends a maximum of 10-12 hours on them.

**Table 4: Weightage distribution for different credit papers**

| Credits | | | | Marks | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory | | | Practical | | |
| L | T | P | Total | IA | | EA | IA | EA (Project) | Total |
| | | | | CE | Project | | | | |
| 2 | 0 | 0 | 2 | 25 | 0 | 25 | 0 | 0 | 50 |
| 3 | 1 | 0 | 4 | 25 | 25 | 50 | 0 | 0 | 100 |
| 3 | 0 | 2 | 4 | 30 | 0 | 40 | 15 | 15 | 100 |
| 0 | 0 | 8 | 4 | 0 | 0 | 0 | 40 | 60 | 100 |
| 0 | 0 | 4 | 2 | 0 | 0 | 0 | 25 | 25 | 50 |
| 2 | 0 | 4 | 4 | 25 | 0 | 25 | 25 | 25 | 100 |

d. For the project work or internship carried out either during the semester or during the summer break (Semester III – Semester VIII), broad guidelines for the evaluation shall be as follows:

**I. Evaluation of projects/ Internship with 4 credits.**

(i) A group of maximum 4 candidates will be mentored by a teacher OR a student/ group of students may be mentored by a responsible person in industry/organisation as assigned by the Programme Coordinator. On completion of the project, the students will submit a brief written report to the ERC. The report will be examined by a board of examiners (one board for 10 students), consisting of three members appointed by the Director, CIC on the recommendation of ERC.

(ii) The evaluation will be on the work carried out by the student, written report and viva/ presentation. 40% weightage will be given to the continuous performance (by the mentor) and 60% weightage for the final assessment (by the board of examiners) after the completion of the project.

**II. Evaluation of 26 Credits Industrial Internship/Major Project (Semester VIII)**

(i) There will be two mid term evaluations of marks 100 and 200 respectively.

(ii) The final evaluation will be of 350 marks. A dissertation should be submitted during the final evaluation. The dissertation will be examined by a board of three members appointed by the Director, CIC on the recommendation of the ERC. A viva-voce examination will be conducted by the board and marks awarded taking into consideration both dissertation and viva.

(iii) The Industrial Internship/ Major Project will be of minimum duration of 20 weeks. A student must complete the internship/ project within six months of the start of the semester. However, ERC may grant extension, not exceeding the maximum duration of the semester but not more than six months at a time.

## B. Tech. (IT & Mathematical Innovations)

### PROMOTION CRITERIA

i. A student who obtains a grade F or Ab in any paper shall have to repeat the paper.

ii. For non-credit courses, 'Satisfactory' or 'Unsatisfactory' shall be indicated instead of the letter grade and this will not be counted for the computation of SGPA/CGPA.

iii. A student who has to reappear in any paper of Semester I/ III/ V/ VII may do so only in the subsequent semester examination for Semester I/ III/ V/ VII respectively. Similarly if a student has to reappear in any paper of Semester II/ IV/ VI may do so only in the subsequent semester examination for Semester II/ IV/ VI respectively.

iv. A student who reappears in any paper shall carry forward the marks of the internal assessment originally awarded to him/her.

v. If a student has an ER in an open elective, and the same open elective is not being offered in the subsequent year, he/ she will have to change the elective. In that case, the student will have to give the internal assessment for the new elective.

vi. Minimum total credit in eight semesters is 204. A student passing a paper will earn the total credit assigned to that paper.

vii. A student shall be eligible for promotion from 1$^{st}$ year to the 2$^{nd}$ year if he/she accrues at least 50% of the total credits in Semester I and Semester II combined. Similarly a student shall be eligible for promotion from 2$^{nd}$ year to the 3$^{rd}$ year if he/she accrues at least 50% of the total credits in Semester III and Semester IV combined (irrespective of the result at the end of the first year). A student shall be eligible for promotion from 3$^{rd}$ year to the 4$^{th}$ year if he/she accrues at least 50% of the total credits in Semester V and Semester VI combined (irrespective of the result at the end of the second year). A student shall be eligible to have passed the 4$^{th}$ year provided he/she earns a minimum of 204 credits during Semester I to Semester VIII.

viii. No student will be held back in Semester I/ III/ V/ VII.

ix. A student who does not satisfy criterion (vii) is required to repeat a year.

### SPAN PERIOD

The total span period to complete the course will not be more than eight years from the year of admission.

### ATTENDANCE

Averaged percentage of attendance to appear in the end semester examination shall be as per University Rules for Undergraduate Degree Examinations at the time.

# B. Tech. (IT & Mathematical Innovations)

## COURSE CONTENT

## SEMSTER – I

**I.1 Seeing the world through calculus. First steps through symbolic mathematics [Theory + Practical] [Semester I] [3 – 0 – 2]**

Limits and continuity - Limits at infinity - Indeterminate forms - Special limits involving exponential and logarithmic functions – Asymptotes - Graphs of function and its derivatives - Optimization problems - Fluency in differentiation - Concavity and inflexion points - Integration - Parametric equations of curves, arc length and surface area - Vector valued functions, differentiation and integration of vector valued functions - Sequences, infinite series including Taylor approximations, Power series - Functions of several variables - Level curves and surfaces - Limits and continuity of functions of two and three real variables - Partial differentiation (two variables), partial derivative as a slope, partial derivative as a rate, Maxima and Minima - Multiple Integrals, line, surface and volume integrals - Applications of Green's, Stokes and Gauss's Theorem.

**Engineering Kitchen Activity (Symbolic Mathematics Software) [Laboratory]**

- Introduction of basic functions
- Plotting of graphs of functions and their derivatives
- Manipulating the parameters in a graph
- Fitting of a curve
- Parametric plot of curves (Eg. Trochoid, Cycloid, Epicycloid)
- Obtaining surfaces of revolution of curves
- Plotting functions of two variables and their level curves
- Graphical illustration of limits for functions of two variables
- Innovation Project

**Outcomes:**

- A good understanding of basic concepts of limits, derivatives, continuity, asymptotes, sequence and series, integrals, vector valued functions, partial differentiation, multiple integrals, etc.
- Able to find points of discontinuity for functions and classify them and understand the consequences of the intermediate value theorem for continuous functions.
- Able to solve applied problems using basic concepts of calculus.
- Able to explain why calculus is valuable in daily life.
- Create a project using the fundamental knowledge and principle of differential and integral calculus that helps to provide a hands-on experience of the same.
- Able to plot and manipulate the curves appropriately to make various real life models like studying the projectile motion in firecrackers and the flow of water in fountain.
- Create animations of given problems using MATHEMATICA software.

## References


1. *Calculus*, T. M. Apostol, Volumes 1 and 2, Wiley Eastern, 1980.
2. *Calculus - Single and Multivariable*, Hughes-Hallett et al., John-Wiley and Sons, 2003.
3. *Calculus*, James Stewart, Thomson, 2003.
4. *Calculus and Analytic Geometry*, G. B. Thomas and R. L. Finney, Addison-Wesley, 1998.


### I.2 Modeling continuous change through ordinary differential equations [Theory + Practical] [Semester I] [3 – 0 – 2]

First order differential equations - Variable separable, homogeneous, linear, exact differential equation - Integrating factors - Existence and uniqueness of solution - General solutions of second order differential equation - Homogeneous and non-homogeneous differential equations with constant coefficients - Method of variation of parameters - Method of undetermined coefficients, higher order differential equations with constant coefficients - Planar autonomous linear systems with graphical representation - Determination of stability and classification of equilibrium of a planar nonlinear system by linearization - Power series solution about a regular point of an analytic ordinary differential equation - Power series solution of Legendre and Bessel's equation - Orthogonality of Legendre and Bessels function - Laplace transform methods applied to differential equations

**Engineering Kitchen Activity (through mathematical software) [Laboratory]**

- Plotting of slope fields and solution curves of first order and higher order differential equations
- Graphical analysis of solution of Population model, Pollution Model, Acceleration – Velocity Models
- Projectile motion, Mechanical Vibrations – Motion of Simple Pendulum, Free undamped and damped motion, Forced undamped and damped motion
- Plotting of phase plane diagrams for predator – prey model, competing species, epidemic model and their analysis
- Innovation project

**Outcomes:**

- Able to explain the fundamental concepts of ordinary differential equations (ODEs) and complex analysis.
- Able to use MATHEMATICA software to solve problems and applications of ordinary differential equations (ODEs) and complex analysis.
- Formulate real life problems as ODEs.
- Able to use concepts of ordinary differential equations to solve physical models such as mass spring, pendulum, alternating current circuits, etc.
- Able to use knowledge of ODEs, the general and particular structure of solutions and different methods for solutions.

## References


1. *Elementary differential equations*, W. E. Boyce and R. DiPrima, John Wiley, 2005.
2. *Differential equations and boundary value problems: Computing and modeling*, C.H. Edwards and D.E. Penny, Pearson education (Singapore), Pte. Ltd., 2005.
3. *Advanced engineering mathematics*, E. Kreyszig, John Wiley, 1999.

**I.3 Automating real world through Programs: Programming Fundamentals [Theory + Practical] [Semester I] [3 – 0 – 2]**

Algorithm and its characteristics-Programming philosophy-Problem solving process-Programming language concepts-Program life cycle-Data definition structures such as types-constants-variables-Expressions such as arithmetic-logical-Precedence and associative rules-Control Structures-Functions-Variable scope-Preprocessing-Arrays, Structures-Strings-Files handling-Pointers-Memory allocation-Coding guidelines-Unit testing & debugging-System testing & Integration

**Engineering Kitchen Activity [Laboratory]**

- User input and output programs having mathematical operations
- Pattern printing programs
- Programs for operators implementation
- Programs to implement function
- Programs to implement collection such as Array and String
- Programs to implement structure
- Innovation Project

**Outcomes:** Following are the outcomes which students will have at the end of the course.

- Will have understanding of Programming Concepts
- Will have understanding of real world applications development through programs
- Will have understanding of independent data and collection of data and their organization
- Will have understanding of memory allocation on runtime
- Will understanding the program life cycle
- Will have understanding of testing, coding guidelines, debugging and integration.

**References:**


1. *C++: The Complete Reference, Fourth Edition*, Herbertz Schildt, McGraw Hill, 2015.
2. *The C++ Programming Language, 4th Edition*, Bjarne Stroustrup, Addison-Wesley, 2013.
3. *Computer Science: A Structured Approach Using C++ 2nd Edition*, Behrouz A. Forouzan, Richard F. Gilberg, 2004
4. *The C Programming Language (Ansi C Version)*, Brian W. Kernighan, Dennis M. Ritchie, 1990.


**I.4 Understanding Computing Systems Architecture [Theory + Practical] [Semester I] [3 – 0 – 2]**

Computer arithmetic: fixed point and floating-point representation and arithmetic, numbers conversion. Digitals circuits: Boolean algebra, logic gates, logical synthesis by minimization of Boolean functions, combinational circuits, sequential circuits (synchronous and asynchronous). Construction of the computer: Von Neumann Architecture, organization and architecture of memory systems, input/output systems, the construction of the simple processor.

**Engineering Kitchen Activity [Laboratory]**

- Logic Gate Designs

- Deconstructing Digital Architecture of a computing devices and study of components (Hardware/Software)
- Hands on experiments with Arduino/ARM Interface
- Programming in Assembler: memory addressing, interrupts, operations on numbers bits and tables, conditional instructions, loops, input/output
- Innovation Project

**Outcomes:** Following are the outcomes which students will have at the end of the course.

- Will have understanding of Computing Systems, Models & Logic, Organization & Architecture of Memory.
- Will have understanding of CPU, I/O Devices
- Will have understanding of Distributed Computing, Parallel Architecture, Mobile Systems Architecture
- Will have understanding about Deconstructing Digital Architecture of a computing devices and study of components (Hardware/Software)
- Will have hands on experience with Arduino/ARM Interface, Programming & interfacing with Sensors and Parallel Programming using OPENMP, OpenMPI & CUDA.

**References:**


1. *Computer System Architecture*, Morris Mano, Pearson Education, 2008
2. *Computer Systems Architecture: a Networking Approach*, Rob Williams, Pearson Education, 2006
3. *Advanced Computer Architecture: Parallelism, Scalability, Programmability*, K. Hwang, McGraw Hill, 2017.


**I.5 Physics at work I: Deconstructing Machines [Theory + Practical] [Semester I] [3 – 0 – 2]**

Newtonian Mechanics (Kinematics & Dynamics) - Classical Mechanics at work - deconstructing mechanical systems - Universal Gravitation - Oscillations - Inertial & Non-inertial frames - Central force motion - Understanding rotational dynamics - Efficiency and mechanical advantage in simple and complex machines: Levers, Pulley, Wheel & Axles, Gear systems, Hydraulic systems - Forms of energy and conversion between different forms of energy.

**Engineering Kitchen Activities [Laboratory]**

- Concepts of measurement, error, precision, accuracy. Concept of scale. Understanding Measuring Instruments
- Understanding oscillation using simple and compound pendulums
- Mechanics system with 850 Universal Interface – understanding Newtonian Dynamics
- Measurement of Moment of inertia from rotational dynamics
- Roller coaster dynamics – computer simulation and physical verification
- Coupled pendulum motion – using webcam and image analysis
- Ballistic Pendulum
- Understanding physics of complex machines – one implementation of "Tod-Phod-Jod" concept.
- Visualization in 3D and understand how things work – Building a CAD model in 3D to trace the flow of power, energy, information and material.
- Innovation project – designing instruments, machines, prototypes, applets

**Outcomes**:

- Understanding of physics principles in machines.
- Ability to conceptualize and build machines for real life use.
- Reverse engineering of mechanical devices and redesigning of such objects.
- Practical hands-on skills and understanding of simple engineering concepts derived from Mechanics.

**References:**


1. *Classical Mechanics*. Herbert Goldstein, Pearson Education, 2011.
2. *A Textbook of Machine Design*. R. S. Khurmi, and J. K. Gupta, S. Chand Publishing, 2005.


**I.6 Business, Entrepreneurship and Innovation Management [Theory] [Semester I] [2 – 0 – 0]**

Understanding Business - Types of Business Activities - Evaluating the Business - Business organization - Starting a Business - Entrepreneurship concept - Entrepreneurial attributes & characteristics – Leadership - Business Plan preparation - B2B and B2C models - Creativity & its components - Invention vs. Innovation - Types of innovation - Innovation and Technology - Innovation policy & IPR - Commercialization of Innovation.

**Outcomes:**

- Have a clear understanding of the types Business activities and organization
- Understand the underlying principles of starting a business
- Identify the Entrepreneurial attributes & characteristics
- Prepare business plans for B2B and B2C models
- Differentiate between Invention and Innovation
- Relate Innovation with technology, existing policies
- Understand the role of IPR in commercialization of innovation

**References**:


1. *Entrepreneurship*. R. D. Hisrich, M. P. Peters, and D. A. Shepherd, D. A., New York: McGraw-Hill / Irwin (New York), 2005
2. *Innovation and entrepreneurship: Practice and principles*. P. F. Drucker, Elsevier, USA, 2006.


**I.7 Environmental Studies and Ecosystem Management [Theory] [Semester I] [3 – 1 – 0]**

Relationship between environment and public health - Sustainable development: policy and practices - Biodiversity: Hotspots, Threats, Conservation - Ecosystem: Structure, Function, Energy flow, cycles - Environmental pollution & public health - Mitigation strategies - Policy - Collection and processing of environmental data - IT in ecosystem & environment management - Social and Cultural parameters - Environmental Risk & Impact Assessment.

**Outcomes:** This paper gives students a general understanding of the interdisciplinary nature of environmental phenomenon and environmental issues. Upon completion of the course the students would be able to-

- Understand the environmental issues, such as natural resource degradation, environmental pollution, biodiversity conservation etc.

- Apply knowledge of mathematics, science, engineering and state-of-the-art technology in the environmental science.
- Design and conduct project studies related to environmental issues
- Analyse environmental data and interpret environmental issues through the data.
- Ability to explain environmental sustainability in a societal, environmental, and economic context.
- Explore the environmental open source database and interpret remotely sensed database.
- Prepare basic cartographic maps

**References:**


1. *Fundamental Concepts in Environmental Studies, D.D. Mishra, (S Chand & Co Ltd.), 2014.*
2. *Environmental Management for Sustainable Development,* Chris Barrow, *(Routledge Environmental Management Series), 2nd Ed.*, 2006.
3. *Essentials of Environmental Management,* Paul Hyde and Paul Reeve, (IOSH Services Ltd. UK.), 2004.
4. *Environmental Impact Assessment Methodologies,* Y. Anjaneyulu, Valli Manicka, (CRC Press), 2011.
5. *Fundamentals of Ecological Modelling*, S.E. Jorgensen and G. Bendorrichio (Elsevier), 3rd Ed., 2001.
6. *Introduction to Environmental Economics*, Nick Hanley, Jason F. Shogren and Ben White, (Oxford University Press), 2001.

## SEMESTER II

### II.1 Linearity in Nature: Engineering through Linear Algebra. First steps through numerical algorithms [Theory + Practical] [Semester II] [3 – 0 – 2]

Algebra of matrices – Determinants - Hermitian, Skew-Hermitian and Unitary matrices - Vectors and vector operations in 2 and 3 dimensions - Solution and application of linear matrix system AX = B - Eigenvalues and eigenvectors, minimal polynomial, Cayley-Hamilton therorem and diagonalisation - Abstract vector spaces, subspaces - Finite dimensional vector spaces - Linear independence and dependence of vectors, bases, dimension of vector spaces - Finite dimensional inner product spaces - Orthogonal sets and projections, Gram Schmidt process, orthogonal diagonalisation

**Engineering Kitchen Activity (matrix based numerical mathematics software) [Laboratory]**

- Basic arithmetic operations, hierarchy of arithmetic operations
- Declaration and assignment of variables
- Introduction to elementary mathematical functions
- Dealing with matrices and arrays
- Basic programming with loops (for, while, switch), if else statements
- Programs for solving system of linear equations, Orthogonalization
- Creating 2D, 3D plots
- Innovation project

**Outcomes:** After completing this course, student should be able to;

- Understand graphical representation of vector and their operations in 2 and 3 dimensions
- Solve linear matrix system AX=B
- Understand the concept of Eigen values and Eigen vectors and their applications in computer graphics, face recognition algorithms & many other fields
- Conceptualize vector spaces, subspaces and their basis functions
- Understand inner product spaces, orthogonal sets, projection and orthogonal diagonalisation
- Learn basic arithmetic operations of matrices in MATLAB
- Implement basic loops (for, while, if else etc) of programming in MATLAB
- Write their own programs for solving system of linear equations

**References**


1. *Linear Algebra and its Applications*, D. C. Lay, Addison Wesley, 2005.
2. *A Modern Introduction*, David Poole, *Linear Algebra,* Brooks Cole, 2011.


### II.2 Understanding real life situation through Discrete Mathematics [Theory] [Semester II] [3 – 1 – 0]

***Combinatorics*:** Sets, counting of sets - Permutation - Combination - Inclusion - exclusion - Generating functions - Recurrence relations - ***Graph Theory*:** Introduction - Basic terminologies - Graph

representation - Euler relation - Isomorphism - Connectivity - Cut vertices and edges - Covering - Euler and Hamilton paths and circuits - Shortest Path Algorithms: Dijkstra's algorithm - Travelling salesman problem - Scheduling problems - Matching - Independent sets - Coloring - **Planar graph**: idea of region - Euler formula - Kuratowski theorem and application - **Tree**: basic terminology, traversal, Prefix code - Idea of data compression: Huffman code - Spanning tree - Minimum spanning tree: Prim's and Kruskal method.

**Outcomes:** After completing this course, student should be able to;

- Understand combinatorics principles: sets, permutations, combinations, recurrence relations etc.
- Conceptualize basic terminologies of graph theory, isomorphism, connectivity etc
- Understand concepts of paths, cycles, circuits and their applications in various fields
- Learn different shortest path algorithms, their computational complexities, implementation & programming
- Understand travelling salesman problem and its importance
- Understand the concept of graph coloring with real applications, planar graphs and algorithms
- Conceptualize trees, spanning trees and algorithms

**References:**


1. *Discrete and Combinatorial Mathematics,* Ralph Grimaldi, International Edition, 2003.
2. *Discrete Mathematical Structures,* Bernard Kolman, Robert Busby, Sharon Ross, International Edition, 2008.
3. *Discrete Mathematics and Its Applications,* K. H. Rosen, McGraw-Hill, 2008.


### II.3 Optimizing Memory use through Data Structure and Design [Theory + Practical] [Semester II] [3 – 0 – 2]

Basic concepts - Dynamic optimization - Memory Hierarchy - Hashing - Networks and Graphs - Search - Heaps

**Engineering Kitchen Activity [Laboratory]:**

- Implementation of Linked list in C/C++
- Implementation of Trees in C/C++
- Implementation of variant of Trees in C/C++
- Implementation of Heaps in C/C++
- Implementation of Hashing in C/C++
- Implementation of Priority Queues in C/C++
- Implementation of Graph and Network based approaches in C/C++
- Innovation Project

**Outcomes**

- Introduction to Data structure and their significance.
- Practical and theoretical understanding of Dynamic optimization
- Basics of Memory Hierarchy and implementation
- Understanding and implementation of Hashing, Networks and Graphs
- Understanding basics and practical aspects of Searching algorithms in the real world through implementation.
- Introduction and implementation of Heaps and Priority Queues and their comparison with other data structure

**References:**


1. *Algorithms and Data Structures*, N. Wirth, Prentice-Hall of India, 2009
2. *Data Structures and Algorithms in C++,* A. Drozdek, Course Technology, 2013


**II.4 Reflecting thought processes through Object Oriented Programming [Theory + Practical] [Semester II] [3 – 0 – 2]**

Introduction to byte code, security and portability, Data Types, variables, operators, arrays, type conversion and casting, type promotion, Control statements, standard input-output, Designing Classes, constructors, methods. access specifiers - public, private, protected, inheritance, packages and interfaces, Math, String, polymorphism - function overloading, function overriding, abstract classes.

Classes and objects - Introduction, Class revisited, constant objects and constructor, static data members with constructors and destructors, constructor overloading, nested classes, objects as arguments, returning objects, constant parameters and member functions, static data and member functions. Dynamic objects - Introduction, array of objects.

Exception Handling - exception types, nested try-catch, throw, throws and finally statements. Multi Thread Programming - thread creation, synchronization and priorities

**Engineering Kitchen Activities [Laboratory]**

- Programs implying the use of Arrays, Linked Lists, Strings, Loops
- Programs on Object & Classes from Realistic Environment and Systems
- Programs demonstrating Constructors, Destructors, Methods & other concepts
- Programs Showcasing Inheritance, Polymorphism, Encapsulation & other OOPS features
- Programs on Exception Handling, Packages and Threading
- Reverse Engineering a Java Source/ project/Mobile Application and understanding the concepts
- Mapping the programs with Real life Systems and showcasing the implementation
- Innovation project

**Outcomes:** Upon Completion of this course the students will be able to:

- Recognise features of object-oriented design such as encapsulation, polymorphism, inheritance, and composition of systems based on object identity.
- Use NetBeans, Eclipse, BlueJ as an Integrated Development Environment. Test a program and, if necessary, find mistakes in the program and correct them.
- Take a problem and develop the structures to represent objects and the algorithms to perform operations.
- Name and apply some common object-oriented design patterns and give examples of their use.
- Apply standards and principles to write truly readable code.
- Design a class that serves as a program module or package.
- Design applications with an event-driven graphical user interface using java applets.
- Design different android applications such as web apps for the real world problems.

**References:**


1. *Java: The Complete Reference*, 10th Edition. Herbert Schildt. McGraw-Hill, 2017.
2. *C++: The Complete Reference*, 4th Edition. Herbert Schildt. McGraw-Hill, 2012.
3. *Object Oriented Programming with C++,* 6th Edition. E Balagurusamy. Tata McGraw-Hill, 2001.
4. *C++ For Artists: The Art, Philosophy, and Science Of Object-Oriented Programming.* Rick Miller, Pulp Free Press, 2008
5. *Java For Artists: The Art, Philosophy, and Science Of Object-Oriented Programming.* Rick Miller , Pulp Free Press, 2008


**II.5 Physics at work II: Deconstructing Devices [Theory + Practical] [Semester II] [3 – 0 – 2]**

Basics of Electrostatics and Electrodynamics - Electric Circuit elements and function - Current, voltage, capacitance, resistance - Power and efficiency in electrical appliances - Joule heating - Electrical safety devices - Basics of Electromagnetism - Electromagnets and induction - Transformers. DC motors and generators - AC motors - Using electromagnetic spectrum - Information transfer and broadcasting - Use of Radiation energy and appliances - Photovoltaic cells and conversion of solar energy to electricity - Advantages, limitations and challenges of different solar cell technologies - Different forms of renewable energy and technology.

**Engineering Kitchen Activities [Laboratory]**

- Electric circuit, power requirement, cost of electricity, energy efficiency of sample appliances
- Potential divider, measurement of resistances of different scales
- Build a buzzer
- Conversion of solar power to electricity using photovoltaic cells: design, working principle, performance, application
- Build an autonomous robot
- Build a remote controlled robot
- Understanding physics of devices – one implementation of "Tod-Phod-Jod" concept.
- Innovation project – designing instruments, devices, model & prototyping

**Outcomes:**

- Understanding of physics principles in devices.
- Ability to conceptualize and build electrical devices for real life use.
- Reverse engineering of electrical devices and redesigning of such objects.
- Practical hands-on skills and understanding of simple engineering concepts derived from Electricity & Magnetism.

**References:**


1. *Introduction to Electrodynamics.* David. J. Griffiths, PHI Learning, 2012
2. *Textbook of Electrical Technology* – Volume I & II. B. L. Thareja, and A. K. Thareja, S. Chand Publishing, 2006

**II.6 Art of communication and Creative Writing [Theory] [Semester II] [2 – 0 – 0]**

Language and Communication - Context - Barriers to communication - speech and writing - writing skills - linguistic unity, coherence, and cohesion - scientific and technical writing - oral interactional skills - formal and informal speech - public speaking - negotiation - group discussion - comprehension - intelligent listening.

Creativity - Poetry - Narrative - Dramatic writing - Creative process - Cultural experience - Creative communication skills in daily life - Retention of traditional narratives - Story telling

**Outcomes:** This paper gives students a general understanding of technical project writing, scientific literature survey, oral presentations and business letter writing. Upon completion of the course the students would be able to-

- Possess substantially improved skills in written and verbal communication.
- Frame technical project writing concepts.
- Understand the importance of secondary database through scientific literature review.
- Research problems and questions and thereby framing the research methodology, subsequently analysing and interpreting the results of the project.
- Present and participate in group discussion during the oral presentation.
- Write business letters.

**References:**


1. *Study Writing: A Course in Written English for Academic Purpose*. Liz Hamp-Lyons, and Ben Heasley, Cambridge University Press, 2006


**II.7.1 Business Process and strategic IT alignment [Theory] [Semester II] [3 – 1 – 0]**

Introduction to different business Processes: Human Resources, Production, Operations, Marketing and Finance - Business process linkage with IT - IT enabled Businesses - IT governance & architecture - IT enabled change management - Business Analysis strategies & planning - Cost Benefit analysis - Enterprise Resource Planning - Digital Marketing and Media - Internet, Multimedia, and Mobile apps in business.

**Outcomes:**

- Understanding various functions of a business organisation
- Able to relate the role of IT in business
- Aware of IT governance and architechture
- Appreciate the need for change management
- Gather a brief idea of Business Analysis strategies & planning , Cost Benefit analysis and ERP
- Understand the way digital marketing operates

**References**:


1. *IT Enabled Business Change - Successful Management*. S. Manwani, The British Computer Society, 2009
2. *Exploiting IT for Business Benefits*, B. Hughes, The British Computer Society, 2009

3. *Projects: Planning, Analysis, Selection, Financing, Implementation, and Review*, P. Chandra, Mc Graw Hill Education, 2009.
4. *E-Business and E-Commerce Management : Strategy, Implementation and Practice*, D. Chaffey, Pearson Press, 2013.

### II.7.2 Electronics at Work & Circuit simulation [Theory] [Semester II] [3 – 1 – 0]

***Analog World:*** resistor, capacitor, inductor, power source, transducer, sensor, detector, switch – Potentiometer - Integrated Circuit – Transformer; ***Digital World:*** logic families, logic gates, boolean algebra - Combinational circuits: adders, encoders, decoders, multiplexer and de-multiplexer - Sequential circuits: like flip flops, counters, shift registers, memories – ***Semiconductor Devices:*** PN Junctions characteristics, Zener and Avalanche breakdown, diode applications, transistor & applications. FET, MOSFET, FET, Operational Amplifier (Op Amp): inverting and non-inverting amplifier, integrator, differentiator, summing amplifier, active filters - ***Signal and System:*** Types, Generation, Audio and Video Signals and their applications, Operation on Signals, Classification of Signals and Systems, Discrete Convolution & Correlation

**Outcomes:**

- It 's an introductory paper to help students get familiar with concepts of Electronics and to assist them in choosing stream options in next semester.
- Familiarizing students with following analog electronic components and their identification: resistor, capacitor, inductor, power source, transducer, sensor, detector, switch, Potentiometer - Integrated Circuit – Transformer;
- Familiarizing students with following digital electronic components, circuits, devices and their identification: logic families, logic gates, Boolean algebra - Combinational circuits: adders, encoders, decoders, multiplexer and de- multiplexer - Sequential circuits: like flip flops, counters, shift registers, memories
- Familiarizing students with following semiconductor devices, circuits and their identification: PN Junctions characteristics, Zener and Avalanche breakdown, diode applications, transistor & applications. FET, MOSFET, FET, Operational Amplifier (Op Amp): inverting and non-inverting amplifier, integrator, differentiator, summing amplifier, active filters
- Familiarizing students with following Signal and Systems: Types, Generation, Audio and Video Signals and their applications, Operation on Signals, Classification of Signals and Systems, Discrete Convolution & Correlation

**Reference:**

1. *Electronic Principles*. Albert Paul Malvino, McGraw-Hill, 1998
2. *Electronic Devices & Circuit Theory*. Robert L. Boylestad, and Louis Nashelsky, Pearson Education, 2009
3. *Digital Logic and Computer Design*. M. Morris Mano, Pearson Education, 2008
4. *Signals and Systems*. Alan V. Oppenheim, Alan S.willsky, and Nawab S.Hamid, Prentice Hall, 1997
5. *Art of Electronics*. Paul Horowitz, and Winfield Hill, Cambridge University Press, 2008

### II.7.3 Exploring Biology: Systems approach [Theory] [Semester II] [3 – 1 – 0]

Biological sciences: from descriptive to reductionist and to systems biology - Introduction to living state and life processes - Origin of life - Cell as a structural unit of life - Metabolism in living state - Living systems as energy machines - Life cycles, Cell cycle & turnover - Origin and diversification of living systems - Hierarchy of organization of living systems (molecular, cellular, and population levels) -

Evolution of living systems: probabilistic versus deterministic - Evidences of evolution, Evolutionary theories, Introduction to molecular evolution.

**Engineering Kitchen Activity [Laboratory]**

- Understanding parts of flower and Placentation in fruit
- Viewing cells, pollens, microbes and biological sections in microscope
- Isolation of cytoplasmic organelle by centrifugation
- Preparation of metaphase chromosome
- Enzyme assay
- Demonstration of osmosis and plasmolysis
- Bacterial growth curve analysis
- Inflorescence models

**Outcomes:** This paper has been designed to initiate students with current ideas and perspective in the field of bioscience. Special care is taken such that a student coming from any course can apprehend the modern biology.

Upon completion of the course, the student will be able

- To understand the diversity and complexity of living systems
- To comprehend different fields within Bio-Sciences
- To understand experimental processes undertaken in Biology
- To know the history of Biology Research
- To ideate on evolution and life

**References:**


1. *Biology*, Raven et al., Tata McGraw-Hill, 2013.
2. *Biology: Global Approach*. Reece et al., Pearson Educations, Global edition, 2014.

## SEMSTER – III

### III.1 Modeling change in the world around us: Partial Differential Equations [Theory + Practical] [Semester III] [3 – 0 – 2]

Familiarities with different type of first order linear and non-linear PDEs - Examples of PDEs arising in transport equation, conservation laws, spread of epidemic cholera - Cauchy problem for first order PDE - method of characteristics, - Monge's cone - Classical methods for simple PDE models. - Second order PDE arising in wave equations, conduction of heat, gravitational potential, telegraph equation, dispersion of contaminants - classification of second order PDE and their solution - Fourier Series and Fourier transforms - Boundary value problem: Dirichlet and Neumann - Lagrange – Green's identity - existence and uniqueness by energy considerations.

**Outcomes:**

- Understand how partial differential equations (PDEs) represent real-world problems.
- Able to use computational tools to solve problems and applications of PDEs.
- Understand the importance of Laplace's equation, heat equation, wave equation, conduction of heat, gravitational potential, telegraph equation, dispersion of contaminants, Fourier series, Fourier transforms, etc. in the theory of PDEs.
- Able to use knowledge of PDEs, the general and particular structure of solutions and different methods for solutions.
- Able to apply the knowledge of PDEs to specific research problems in different fields.

**References**


1. *Partial Differential Equations*, E. DiBenedetto, Birkhauser, Boston, 1995.
2. *Partial Differential Equations*, Fritz John, Narosa Publ. Co., New Delhi, 1979.
3. *Linear Partial Differential Equation for Scientists and Engineers*, Tyn Myint-U and Lokenath Debnath, Springer, Indian reprint, 2006.
4. *Partial Differential Equations: An Introduction with Mathematica and MAPLE*, Ioannis P Stavroulakis and Stepan A Tersian, World Scientific, 2004.


### III.2 Design and Analysis of Algorithm [Theory] [Semester III] [3 – 0 – 2]

Algorithmic analysis and modeling - Algorithmic proofs - Computational complexity - Asymptotic notation and analysis – Sorting methods analysis – Randomization – NP Completeness – Advanced data structure – Geometric algorithms – Graph algorithms – Linear Programming – Design paradigm such as Divide & conquer – Dynamic Programming – Greedy Approaches – Search heuristics – Approximation algorithms – Compression and streaming algorithms – Distributed and parallel algorithms.

**Engineering Kitchen Activity [Laboratory]:**

- Hands on experiments for time and space complexity of Sorting algorithms.
- Hands on experiments for time and space complexity of Dynamic programming and Greedy approaches.
- Hands on experiments for time and space complexity of Search heuristics.
- Hands on experiments for time and space complexity of Approximation algorithms.
- Hands on experiments for time and space complexity of Compression and streaming algorithms.
- Hands on experiments for time and space complexity of Distributed and Parallel algorithms.
- Innovation Project – Algorithms design for real world problems.

**Outcomes**

- Basics of algorithmic analysis and their practical understanding of the real world examples.
- Learning mathematical design of algorithms and their algorithmic correctness through proofs.
- Understating computational complexity with asymptotic notations and their analysis.
- Introduction of different types of paradigm and domain of algorithms such as NP-completeness.
- Hands on experiments on dynamic programming and greedy approaches.
- Hands on experiments on advanced data structures such as AVL tree and Red black etc.
- Hands on experiments of Search heuristics and Approximation algorithms.
- Hands on experiments of Distributed and parallel algorithms.

**References:**


1. *Introduction to Algorithms*. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. MIT Press, 2009.
2. *Problem Solving with Algorithms and Data Structures Using Python*. Bradley W. Miller, and David L. Ranum. Franklin, Beedle & Associates, 2011.
3. *Data Structures and Algorithms in C++,* A. Drozdek, Course Technology, 2013
4. *The Art of Computer Programming, Vol. 1,2,3,4*. Donald E. Knuth, Pearson Education, 2013.


**III.3 Handling information through Data Modeling & Design [Theory + Practical] [Semester III] [3 – 0 – 2]**

Traditional Files & Databases – Database Management Systems – Relational Model - ER Modeling – Constraints, Query language & features – Normalization – Indexing – Transaction Processing & Concurrency Control – PL/SQL Basics – Graph Databases - Data Modeling Techniques & UML – Analysis of Data using Mining Techniques – MongDB - NoSQL – Object Oriented Databases - Study of Real World Applications

**Engineering Kitchen Activity [Laboratory]**

- ER Diagram of Existing systems and new systems
- SQL Commands, Structures & execution of Commands on Test Database
- Creation of Databases and identifying the Constraints
- Execution of DDL, DML, TCL Queries on created database
- XML Databases
- Executing Aggregate Functions and Extraction of Data elements
- Programs on Database Objects including Procedures, Functions, Exception
- Modeling of Systems and Requirements using UML
- Design of Application(s) using Mining Techniques
- Reverse Engineering & Study of a Database System Architecture
- Innovation Project

**Outcomes:** Upon Completion of this course the students will be able to:

- Install, configure, and interact with a relational database management system.
- Describe, define and apply the major components of the relational database model to database design.
- Learn and apply the Structured Query Language (SQL) for database definition and manipulation.
- Utilize a database modelling technique for a single entity class, a one-to-one (1:1) relationship between entity classes, a one-to-many (1:M) relationship between entity classes, a many-to-many (M:M) relationship between entity classes, and recursive relationships.
- Define, develop and process single entity, 1:1, 1:M, and M:M database tables.
- Learn and implement the principles and concepts of information integrity, security and confidentiality.
- Apply ethical computing concepts and practices to database design and implementation.

**References:**


1. *Fundamental of Database Systems*, R. Elmasri and S. B. Navathe, Pearson Education Asia, 7th edition, 2016.
2. *Database System Concepts*, Abraham, H. and Sudershan, S., 5 Ed., McGraw-Hill, 2013
3. *Introduction to Data Mining*, Pang, N. T., Pearson Education, 2013
4. *Database System : The Complete Book*, Jeffrey Ullman, Jennifer Widom, and Héctor García-Molina, Pearson Education, 2008
5. *Data Modeling: A Beginners Guide*, Andy Oppel, McGrew Hill, 2010


### III.4 Language and Communication: Computational Linguistics [Theory] [Semester III] [2 – 0 – 0]

Introduction to Natural Language Processing (NLP) - Language structure and Analyzer - Morphological Analysis - Local Word Grouping - Parsing - Computational grammar and requirements - Machine Translation - Lexical semantics and algorithms – Spoken Language System – Tagging – Speech synthesis – Speech recognition

**Outcomes:** Upon Completion of this course the students will be able to:

- Analyse language using computer.
- Design a simple computer program for language analysis.
- Be able to distinguish between human capacity and ability from machine /computer capacity and ability.
- Apply techniques that are being widely used in search engines, digital libraries, speech recognition systems, and NLP data mining toolkits.
- Apply syntactic and semantic analysis to natural language.
- Engage in speech synthesis and in machine translation.

**References:**


1. *Natural Language Processing*, A. Bharati, V. Chaitanya, R. Sangal, Prentice Hall India, 1995
2. *Natural Language Processing with Python: analyzing text with the Natural Language Toolkit*, Steven Bird, Ewan Klein, and Edward Loper, O'Reilly, 2009.
3. *Speech and language processing: an introduction to natural language processing, computational linguistics, and speech recognition* (2nd edition), Daniel Jurafsky and James H. Martin, Pearson International, 2009

**III.5.1 Understanding Economic Behavior: The micro level [Theory] [Semester III] [3 – 1 – 0]**

Exploring the subject matter of Economics - The Economic Problem: Scarcity and Choice; the question of What to Produce, How to Produce and How to Distribute Output, Markets and Competition; Determinants of individual demand & supply, Demand-Supply schedule and curves, Market versus individual demand & supply, Shifts in the demand & supply curve, Market Interactions, How Price allocate resources, Elasticity and its application, Controls on Prices, Taxes and the Costs of Taxation, Households and Consumer Behavior, Budget Constraints, Firms and Producer Behavior, Perfect Market Structure, Imperfect Market Structures; Monopoly and antitrust policy, government policies towards competition, Imperfect information in the product market--The information problem, The market for lemons and adverse selection and Input Markets.

**Outcomes:**

- Understanding of the basic structure of the economic ecosystem.
- Conception, of how individuals and firms allocate resources and how market prices are determined.
- It introduces a framework for learning about consumer behaviour and analysing consumer decisions.
- Students will be able to understand shifts in supply and demand and their implications for price and quantity sold.
- Student will also learn how to analyse how consumers respond to a shift in the price of the goods they consume.
- Understanding of how to analyse firms' decisions mathematically using a production function and calculate their optimal level of production, costs, and profits.
- Learn to model the decisions made by firm in a monopoly and an oligopoly, and the implications of these alternate structures for consumer welfare.

**References**


1. *Principles of Economics*, K. E. Case, R. C. Fair and S. C. Oster, Pearson Education, 10th Edition, 2011.
2. *Principles of Economics,* N. G. Mankiw, South-Western, 6th Edition, 2011.
3. *Intermediate Microeconomics,* Hal R. Varian, W.W. Norton & Company and Company/Affiliated East-West Press (India), 8th edition, 2010.
4. *Microeconomics,* R. S. Pindyck and D. L. Rubinfeld, Pearson Education, 8th Edition, 2012.


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**III.5.2 Electronics circuit elements and instruments [Theory] [Semester III] [3 – 1 – 0]**

AC Fundamentals - Concept of voltage and current sources - KVL and KCL - Node voltage analysis and method of mesh currents - Network theorems - PN Junction: variants and applications - Bipolar Junction Transistor (BJT) biasing and amplifier design - Field Effect Transistor (FET) variants – FET biasing and amplifier design - Structure and working of SCR. Structure and operation of LDR, Photo voltaic cell, Photo diode, Photo transistors and LED, Operational Amplifiers basics and practical circuits - Feedback and oscillator circuits -Voltmeters- Multimeters - Function generator- Cathode ray oscilloscope - Cathode Ray Tube.

**Outcomes:** Upon completion of this course the students will achieve understanding of the following:

- Concepts of AC fundamentals
- Good knowledge of Network Analysis
- Basics of Diodes and Transistor based devices
- Knowledge of instrument like CRO, Function Generator, Multimeter, etc.

**References**


1. *Circuits and Networks* - A.Sudhakar & Shyammohan S. Palli ,TMH, 2010
2. *Principles of Electronics*- V.K. Mehta and Rohit Mehta, S Chand &Co,2009
3. *Electronic Devices and Circuit Theory*-R.L.Boylestad and L.Nashelsky, Pearson Education, 2009.


### III.5.3 Integrative Biology [Theory] [Semester III] [3 – 1 – 0]

Demystifying living state - Central process in transmission of information - Choice of the genetic material - RNA world - Designing living systems - Nature of biological processes - Approaches to study Biology: Observational and Experimental, Physiology and Behaviour - the regulated activities - Communication (external & internal) as the basis of regulation - Circuits and regulations in living systems - Interaction of biological components - Information flow in living systems: Proximate and Ultimate causes - Model organisms in study of Biology - Chaos and Order.

**Outcomes:** In this paper subjects of different streams are incorporated in a holistic manner to give a broad overview of biological sciences.

Upon completion of the course, the student will be able

- To comprehend current research in different streams of Biological Sciences
- To get in depth knowledge of how living system functions (regulation, communication)
- To know about different model system and their utilization in biology
- To apprehend study design in biology
- To get an idea of career prospects in bioscience
- To design small innovative research projects in biosciences.

**References:**


1. *An Introduction to Systems Biology: Design Principles of Biological Circuits,* Uri Alon, Chapman & Hall, 2nd edition, 2013.
2. *Physical Biology of the Cell***,** Phillips et al., Garland Science, 2nd edition, 2012.
3. *Molecular Cell Biology*, Lodish et al., W. H. Freeman & Company, 7th edition, 2012.
4. *Biochemistry*, Berg, Tymoczko and Stryer, W H Freeman & Company, 7th edition, 2011.


### III.6.1 Principles of Management [Theory] [Semester III] [3 – 1 – 0]

Evolution of Management Thoughts, contribution of selected management thinkers, Approaches to management, Contemporary Management practices in Global Environment, Management Functions: Planning, Organizing, Staffing and controlling, Introduction to various streams of management.

**Outcomes:**

- Discuss and communicate the management evolution and how it will affect future managers.
- Understanding the concept of growth strategies and its use for sustaining in business.
- Learn to analyse alternatives in a decision-making process.
- Understanding the concept of Organizational Citizenship Behaviour (OCB) for measuring performance in which any job or task takes place.

- Understanding how, the social process by which people interact and behave in a group.
- Learn and identify the roles which are fulfilled while working as a manager.
- Understanding, define, appreciate and apply of views of theories of motivation.
- Learn the relationship between leaders and followers.
- Students will learn to includes adapting to the change, controlling the change and effecting new change.
- Understanding the current theories, practices, tools and techniques in knowledge management (KM) to deal with the challenges with the organization and management of knowledge.

**References**


1. *Management Concepts and Strategies,* J.S.Chandan, Vikas Publishing House, 2010.
2. *Management Concepts and Practices*, Tim Hannagan, Macmillan India Ltd., 5th Edition, 2009.
3. *Essentials of Management,* Koontz, Tata McGraw-Hill, 7th Edition, 2006.


**III.6.2 Electronics circuit elements and instruments – Innovation Lab [Practical] [Semester III] [0 – 0 – 8]**

**Engineering Kitchen Activity [Laboratory]**

- Characteristics of PN junction and Zener diode
- Half wave rectifier.
- Full wave rectifier with 2 diodes.
- Full wave rectifier with 4 diodes (Bridge rectifier).
- Input, Output and Transfer characteristics of CE and CC Amplifier.
- Characteristics of LDR, Photo-diode and Photo transistor.
- Transfer characteristics of JFET.
- Transfer characteristics of MOSFET ( with depletion and enhancement mode)
- Characteristics of LED with three different wavelengths.
- Series voltage Regulator.
- Shunt voltage Regulator.
- Characteristics of Thermistor

**Outcomes**: Upon completion of this course the students will achieve understanding and practical knowledge of the following:

- Characteristics of Diodes and Transistors and its application
- Full and half wave Rectifiers, filters and power supply
- Functioning of Amplifier
- Fundamentals of photo diode, photo transistor and solar cell and its applications

**III.6.3 Cell: Biochemical and Molecular perspective [Theory] [Semester III] [3 – 1 – 0]**

Bioenergetics and Metabolism - Energy transduction in the living organisms (photosynthesis and respiration) - Cell organelles, Cell membrane and extracellular matrix - Cytoskeleton and membrane trafficking - Cell division and checkpoints - Cell signalling - Origin of eukaryotes: hypothesis - Enzyme and enzyme kinetics.

**Outcomes:**

- This course acquaints students with basic principles related to cell, as the smallest unit of an organism, where students are exposed to the understanding of all components of a cell, its organelles, cell membranes, all types of possible molecular interactions which take place during various cellular processes.
- An understanding on the most relevant and basic topics like photosynthesis, respiration and the energetics involved during these processes would facilitate the generation of curiosity among students about the most complicated biological machineries as a whole.
- Students would be able to understand the concepts of origin of prokaryotes and eukaryotes and probably would be able to at least grab the knowledge of many unanswered queries related to biological processes, which later may act as a fuel in developing their research temperament.

## References


1. *The cell: A Molecular Approach*, Geoffrey M Cooper, Sinauer Associates 6th edition, 2013.
2. *Molecular Biology of the Cell* , Alberts et al., Garland Science, 5th edition, 2007.
3. *Molecular Cell Biology*, Lodish et al., W. H. Freeman & Company, 7th edition, 2012.
4. *Biochemistry*, Berg, Tymoczko and Stryer, W H Freeman & Company, 7th edition, 2011.

## SEMSTER – IV

### IV.1 Does Nature play dice?: The amazing world of probability and statistics [Theory + Practical] [Semester IV] [3 – 0 – 2]

Probability space - Conditional probability - Bayes theorem – Independence - Descriptive measures (Mean, median, mode, standard deviation, dispersion, moments) - Random variables - Joint distributions - Discrete distributions (Bernoulli, Binomial, Poisson) and their properties (Expectation, variance, conditional expectation, moments) - Continuous distributions (Uniform, Normal, Exponential) with their properties (Expectation, variance, conditional expectation, moments) - Joint, marginal and conditional distributions - Weak and strong law of large numbers, -Central limit theorem - Sampling distributions - Hypothesis testing, interval estimation - Likelihood, analysis of categorical data - Curve fitting - linear regression, Correlation - Test statistic and their significance.

**Engineering Kitchen Activity [Laboratory]**

Computer program R and its application to simple models

- Introduction to basic syntax of R for arithmetic operations, creating arrays and matrices
- Getting data into R and basic data analysis in R
- Statistical computations in R (evaluation of density functions and distribution functions, computation of descriptive measures for given data)
- Data visualization in R

**Outcomes:**

- A good understanding of basic concepts of statistical distributions.
- A good understanding of elementary probability theory, the laws of probability and the use of Bayes and various other theorems of probability.
- Able to derive the probability density functions of transformations of random variables and use these to generate data from various distributions.
- Able to represent and statistically analyze data both graphically and numerically.
- A good understanding of exploratory data analysis by working on datasets related to human resources, image segmentation analysis, pollution levels in a city, health diagnosis, etc. along with the ability to write a short-report describing a simple statistical data set.
- Able to translate real-world problems into probability models.

**References**


1. *Introduction to Probability and Statistics for Engineers and Scientists*, S.M. Ross, Academic Press, 2009.
2. *Applied Statistics and Probability for Engineers,* D.C. Montgomery and G.C. Runger,John Wiley and Sons, 2014.
3. *Design of Experiments: A No-Name Approach*, Thomas Lorenzen and Virgil Anderson, CRC Press 1993.
4. *Statistics and Experimental Design in Engineering and the Physical Sciences*, Vol. I and II, N.L. Johnson and F.C. Xeen Leone, Wiley Interscience, 1977.


### IV.2 Instructing computing devices: Operating System [Theory] [Semester IV] [3 – 1 – 0]

Overview: Operating systems – structure, operations, components, types, services, user interfaces. System calls, system programs, system boot. Process management - Processes: concept, scheduling,

operations on processes, inter-process communications. Threads – single - and multi-threaded processes. CPU scheduling – criteria, algorithms, multiple-processor scheduling. Process synchronization – critical-section problem, semaphores, classic synchronization problems, monitors. Deadlocks – characterization, deadlock prevention, deadlock avoidance, deadlock detection, recovery from deadlock. Memory management: Main memory – memory allocation schemes, paging, segmentation, Virtual memory, file management.

**Outcomes:** Upon Completion of this course the students will be able to:

- Analyse the structure of OS and basic architectural components involved in OS design.
- Analyse and design the applications to run in parallel either using process or thread models of different OS.
- Analyse the various device and resource management techniques for timesharing and distributed systems.
- Understand the Mutual exclusion, Deadlock detection and agreement protocols of Distributed operating system.
- Interpret the mechanisms adopted for file sharing in distributed Applications.
- Conceptualize the components involved in designing a contemporary OS.

**References:**


1. *Operating System Concepts*, 10th Edition, Abraham Silberschatz, Peter Baer Galvin, Greg Gagne, John Wiley & Sons, 2009
2. *John. Lions' Commentary on UNIX® 6th Edition with Source Code.* John Lion, San Jose, CA: Peer-to-Peer Communications, 1996
3. *Exokernel: An Operating System Architecture for Application-Level Resource Management.,* Engler, Dawson R., M. Frans Kaashoek, and James O'Toole Jr., ACM Press, 1995.


**IV.3 Information exchange in computing devices: Data Communication & Networking [Theory + Practical] [Semester IV] [3 – 0 – 2]**

Communication Channels - Topologies - Networking Applications – Layered Architecture & Models – Network Devices – Error Management – Network Protocols – Network Security & Cryptography – Network Architectures of Enterprise Applications

**Engineering Kitchen Activity [Laboratory]**

- Hands on experiment with Network Topologies on LAN/WAN – Wired & Wireless
- Hands on Experiments with Routing Mechanism in Internet and Intranet
- Setting up TCP/UDP applications on Network Devices
- Socket Programming
- Use of Wire shark for Packet Analysis
- Study Security protocols & certificates
- Study of Streaming Applications and Protocols
- Design of Web/Server Based Applications
- Reverse Engineering the Network Protocols
- Innovation Project

**Outcomes:** Following are the outcomes which students will have at the end of the course:

- Will have understanding of Data communication, Communication Channels, Topologies and Networking Applications.
- Will have knowledge of Layered Architecture & Models, Network Devices, Error Management, Network Protocols and Network Security & Cryptography.
- Will have exposure to Network Architectures of Enterprise Applications and Hands on experience of Network Topologies on LAN/WAN – Wired & Wireless
- Will be able to understand the Routing Mechanism in Internet and Intranet, Setting up TCP/UDP applications on Network Devices, Socket Programming, Web/Server Based Applications.

**References:**


1. *Data Communication and Networking*, Forouzan, B.A., Tata McGraw-Hill. 2013
2. *Computer Networking: A Top-Down Approach Featuring the Internet*, Kurose, J.F. and Ross, K.W., 3rd Ed., Addison Wesley, 2004
3. *Computer Networks, A S Tanenbaum*, PHI, IV Ed, 2003
4. *Computer Communication Networks*, W. Stallings, PHI, 1999


**IV.4 Science, Philosophy, Truth: Impact of technology [Theory] [Semester IV] [2 – 0 – 0]**
(This is only a suggestive syllabus. There is no fixed syllabus for this unit)

Philosophy of Science – Methodology of Science – Science as a pursuit of truth: Theory of falsification by Karl Popper and theory of paradigm shift by Thomas Kuhn - Evolution of science driven technology and technology driven science – Exploring scales.

Science & Ethics - This course will also engage social ethics in response to its impact on the developing technologies of global societies. We will explore the idea that traditional concepts of ethics insist that people in social relationships be treated as ends, in and of themselves, and never as means to the ends of others. Since all technologies evolve from our social relationships, no technology is value-free. Because of the value-laden nature of technological developments, new technologies are characteristically defined as both socially-determinative and socially derived.

**Outcomes:** This paper covers the philosophy of Science, methodology of Science, historical development of modern science, science as a pursuit of truth. Upon completion of the course the students would be able to-

- Have an understanding of major themes in the development of science.
- Identify philosophical issues about the methods of science.
- Possess a thorough knowledge of selected areas in history, philosophy and sociology of science.
- Be capable to do research in unfamiliar subject areas quickly and efficiently.
- Be capable of pursuing an in-depth project

**References**


1. *The Principia: Mathematical Principles of Natural Philosophy*, Isaac Newton, University of California Press, 1999.
2. *Truth and Beauty: Aesthetics and Motivations in Science*, S. Chandrasekhar, University of Chicago Press, 2013
3. *What is life?*, Erwin Schroedinger, Cambridge University Press, 1992.
4. *Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity*, Steven Weinberg, Wiley, 1972
5. *Phantoms in the Brain : Human Nature and Architecture of the Mind* , V. S. Ramachandran, Fourth Estate, 1998.

6. *The logic of Scientific Discovery*, Karl Popper, Routledge, 2005.
7. *The Structure of Scientific Revolution*, Thomas Kuhn, University of Chicago Press, 2012.

**IV.5.1 Understanding Economic Behaviour: The macro level [Theory] [Semester IV] [3 – 1 – 0]**

GDP Measurement Techniques, Classical and Keynesian Theories- Macroeconomic Equilibrium, labor market, product market, Full Employment, Aggregate Expenditure Model, , Role of money and the Government, Monetary and Fiscal Policy, The multiplier effect, Inflation, Exploring the macroeconomics of an open Economy: international Economics; Balance of Payments--The current and capital account; Determining equilibrium output in an open economy; Open economy with flexible exchange rates--Markets for foreign exchange, Factors affecting exchange rates, effects of exchange rates on the economy

**Outcomes**

- Student will learn to perceive the nation's economy as a whole and compare the views of Keynes and the classical economists.
- Learn various techniques measuring and tracking macroeconomics using GDP and CPI.
- Analyse the model of full employment and use it to examine important macroeconomic issues, such as the extent to which taxes may depress economic activity and lower the level of GDP.
- Understanding of the importance of the multiplier, the aggregate consumption function and how expected future income and aggregate wealth affect consumer spending.
- The aggregate demand and aggregate supply curves form an economic model that will enable students to learn, how output and prices are determined in both the short run and the long run.
- Equip students to examine the concept of unemployment and inflation and their cost implication on society.
- Demonstrate an understanding of monetary and fiscal policy options as they relate to economic stabilization in the short run and in the long run.
- Learn to analyse the causes and correction of disequilibrium of balance of payment.
- Examine the balance of payments current account and capital account for national economy.
- Acquire the understanding the working of FOREX market and mechanism of determining exchange rate under different exchange rate regime.

**References**


1. *Macroeconomics,* R. Dornbusch, S. Fischer and R. Startz, McGraw Hill, 11th edition, 2010.
2. *Macroeconomics,* N. G. Mankiw, Worth Publishers, 8th edition, 2012.
3. *Principles of Economics*, K. E. Case, R. C. Fair and S. C. Oster, Pearson Education, 10th Edition, 2011.
4. *International Economics*, Dominick Salvatore, John Wiley & Sons, 2007.
5. *Macroeconomics*, Robert J. Gordon , Prentice-Hall India Limited, 2011


**IV.5.2 Digital electronics and logic design [Theory] [Semester IV] [3 – 1 – 0]**

Boolean algebra – Logic Gates – CMOS circuits – PLA - Digital IC families – Combinatorial circuits – Sequential circuits – MSI and PLD components – ADC – DAC – Semiconductor memories – Microprocessor – Assembly Language – I/O Interfacing – Data Transfer Techniques – Finite State Machine - Firmware design

**Outcomes:**

- Students shall be able to design and analyze electronic circuits based on: Boolean algebra, Logic Gates, CMOS circuits, PLA, Digital IC families, Combinatorial circuits, Sequential circuits , MSI and PLD components , ADC , DAC, Semiconductor memories.
- Students shall learn importance of following in digital circuit designing: Microprocessor , Assembly Language, I/O Interfacing
- Equipping students with following: Data Transfer Techniques, Finite State Machine, Firmware design

## References


1. *Digital Design* - M. Morris Mano, Prentice Hall of India, 2006
2. *Digital Logic Design Principles*, Balabanian, N. and Carlson, B.,John Wiley & Sons, 2001
3. *Digital Fundamentals*, Floyd, T.L., 8th Ed., Pearson Education, 2005


### IV.5.3 *in silico* Biology [Theory + Practical] [Semester IV] [3 – 0 – 2]

Sequence analysis and alignment – Promoter domains and motifs – Scoring matrices – Biological databases and data-mining – Phylogeny and cladistics – Structure analysis – Molecular modelling and simulations – Bio-statistics – Stochastic models – Algorithm and programming language.

**Engineering Kitchen Activity [Laboratory]**

- Sequence analysis (BLAST, FASTA).
- Database (NCBI, DDBJ, EMBL).
- Motif and Promoter searches (e.g. CD-Search, SMART, SignalP)
- Phylogenetic analysis (PHYLIP, MEGA)
- Protein interaction (STRING, BioGRID)
- Protein structure, Function (PROSITE programs, Chimera
- Gene expression, function (GEA, Gene card, OMIM)
- Introduction to molecular docking

**Outcomes:** The students will be able to perform small bioinformatics projects after the completion of this course. They will be able to know about several important bioinformatics software. After completion of this paper the students will be well versed in

- Gene and protein alignment tools
- Finding domains and motifs in protein sequences
- Homology based modeling of proteins and docking

They will also be equipped to build

- Cladograms
- Prediction of active sites in a protein,
- Energy calculation for stabilization of DNA-protein and protein-protein complexes.

## References


1. *Bioinformatics: Sequence and genome analysis*, David mount, Cold Spring Harbor Laboratory Press; 2nd edition, 2013.
2. *Introduction to Bioinformatics*, Arthur M. Lesk, OUP Oxford, 4th edition, 2014.


### IV.6.1 Bringing Companies and clients together: Sales & Marketing management [Theory] [Semester IV] [3 – 1 – 0]

Concepts – Strategies - Marketing Mix - Buyer Behavior Models - Marketing Research and trends in Marketing - Advertising and Branding - E-Business Marketing - IT-Enabled capabilities that influence marketing strategies.

**Outcomes:**

- Understanding the concept of marketing and marketing process.
- Understanding the Marketplace and Consumer by analysing the marketing environment
- Students will get a closer look at final consumer buying influences and processes and the buyer behaviour of business customers.
- Designing a Customer Value–Driven Strategy and Mix.
- Understanding of key customer value–driven marketing strategy decisions—dividing up markets into meaningful customer groups (segmentation), choosing which customer groups to serve (targeting), creating market offerings that best serve targeted customers (differentiation), and positioning the offerings in the minds of consumers (positioning).
- Learn, how the companies develop and manage products, services, and brands.
- Understanding of new products and managing products through their life cycle.
- Learn pricing mechanism and their pricing strategies, and look at internal and external considerations that affect pricing decisions.
- Students learn to explore the nature of marketing channels, the marketer's channel design, management decisions and distribution.
- Understanding of the characteristics of different kinds of retailers and wholesalers, the marketing decisions they make, and trends for the future.
- This course will help them to examining the concepts of direct marketing and its fastest-growing form: digital marketing (online, social media, and mobile marketing).
- Understanding the need of sustainable marketing, meeting the needs of consumers, businesses, and society—now and in the future—through socially and environmentally responsible marketing actions.

## References


1. *Marketing,* M. J. Etzel, J. W. Bruce, W. J. Stanton, & A. Pandit, New Delhi: Tata McGraw-Hill, 14th edition, 2010.
2. *Marketing management: a south Asian perspectiv*e, P. Kotler, K. Keller, L. Koshy & M. Jha, New Delhi: Pearson, 13th Edition, 2009.
3. *Marketing management: Global perspective Indian context,* V. S. Ramaswamy, & S. Namakumari, New Delhi: Macmillan, 4th Edition, 2009.
4. *Marketing management,* R. Saxena, New Delhi: Tata McGrawHill, 4th Edition, 2009.

**IV.6.2 Digital electronics and logic design – Innovation Lab [Practical] [Semester IV] [0 – 0 – 8]**

**Engineering Kitchen Activity [Laboratory]**

- Realization of logic gates through diodes and resistors
- Verification of Boolean algebraic functions through digital IC gates
- Design of half/full adder and sub tractor circuits
- Design of shift registers using flip-flops
- Circuit design and simulation software and EDA

**Outcomes:**

- Providing students hands on experience of circuit designing through activities in Engineering Kitchen Laboratory
- Actual designing of following electronic circuits: Realization of logic gates through diodes and resistors, Design of half/full adder and sub tractor circuits, Design of shift registers using flip-flops
- To learn process of verification of Boolean algebraic functions through digital IC gates
- To learn circuit design and simulation software and EDA
- Implementing students own ideas on circuit designing under guidance of mentor through Innovation Projects

**IV.6.3 Flow of information in living systems [Theory + Practical] [Semester IV] [3 – 0 – 2]**

Experimental evidences for the nature of genetic material – Process of information transfer (Replication, Transcription and translation machinery) – Energetics and accuracy of information transfer – Problems of information transfer (DNA damage and repair) – Regulation of informational transfer (transcription factors, operon) – DNA packaging and chromatin structure, regulation of gene expression in eukaryotes.

**Engineering Kitchen Activity [Laboratory]**

- Agarose Gel Electrophoresis
- SDS-PAGE Electrophoresis
- Polymerase Chain Reaction (PCR)
- Primer design
- Spectrometry
- Analysis of growth curve, molar extinction coefficient, absorption maxima
- Biochemical assays
- Restriction digestion
- Introductory Gene Cloning (Transformation to Ligation).

**Outcomes:**

- The importance of DNA and RNA as genetic material is very well known to everyone, during this course, the students would be able to understand all the relevant concepts about structure and function of these biomolecules
- Students would also learn in detail about the processes taking place as a part of central dogma of a cell where the most relevant topics of replication, transcription and translation are introduced to students, which further facilitate in building up a relationship between these biological processes.

- Since DNA damage and repair are a part of this course, students would be encouraged to understand and take up such projects, where they might be involved with the real-time working to find answers to many unanswered questions.
- Engineering kitchen being one of the significant part of this course would be able to inculcate practical and hands-on skills among students for working on various projects.

## References


1. *Molecular Cell Biology*, Lodish et al., W. H. Freeman & Company, 7th edition, 2012.
2. *Biochemistry*, Berg, Tymoczko and Stryer, W H Freeman & Company, 7th edition, 2011.

## SEMSTER – V

### V.1 Complexity and Symmetry in Mathematics: Complex Analysis and Algebra [Theory + Practical] [Semester V] [3 – 1 – 0]

Functions of complex variable - Derivatives, differentiation formulas - Cauchy-Riemann equations - sufficient conditions for differentiability - Analytic functions of a complex variable: Power-series expansions, Laurent expansions and Liouville's theorem - Complex integration - Cauchy Integral Theorem - Residue Theorem and applications to evaluate real integrals.

Sets, relations, functions - Groups, subgroups - Permutations – Cyclic notation of permutation – Even and odd permutations - Permutation groups – Alternating groups – Subgroups – Lagrange's theorem and its consequences – Cyclic and Abelian groups – Centralizer and normalizer of a group, Symmetries of plane figures

**Outcomes:**

- Understand the significance of limit, continuity and differentiability for complex functions.
- Evaluate integrals along a given path and compute the Taylor and Laurent expansions of complex functions.
- An introduction to the fundamentals of group theory
- Visualization of the applications of group theory

**References**


1. *Complex Variables and Applications*, J.W. Brown and R. V. Churchill, McGraw Hill (8th Edition), 2009.
2. *Contemporary Abstract Algebra*, J. A. Gallian, (8th Edition), Cengagae Learning, 2013.
3. *An Introduction to Theory of Groups*, J. J. Rotman, (4th Edition), Springer, 1995.


### V.2 Computer Graphics and Visualization Architecture [Theory + Practical] [Semester V] [3 – 0 – 2]

Overview of Computer Graphics - Usage of Graphics and their applications, Over view of Graphics systems - Refreshing display devices, Random and raster scan display devices, Colour Models: RGB, HSV etc., Tablets, Joysticks, Track balls, Mouse and light pens, plotters, printers, digitizers. Output primitives - DDA Line drawing algorithm, Bresenham's Line Drawing Algorithm, Mid-point circle algorithm, Mid-point Ellipse algorithms. Transformations - Basic 2D Transformations, Matrix representations & Homogeneous Coordinates, Matrix Representations for basic 2D and 3D transformations, Composite Transformations, reflection and shear transformations. Two dimensional viewing - Barky line clipping algorithm, Algorithm for polygon clipping, Sutherland-Hodgeman polygon clipping, Curves - Bezier Curves, 4 point and 5 point Bezier curves using Bernstein Polynomials. Shading and Hidden Surface Removal - Shading, Guard Shading, Phong Model, Back Face Detection, Depth Buffer (Z-Buffer, A-Buffer) Method

**Engineering Kitchen Activities [Laboratory]:**

- Programs related on different concepts
- 2D and 3D transformation modeling
- Concept of Animations and Motion Pictures
- Smart Interfaces
- Virtual Augmentation applications in security, medicine and manufacturing

- Indexing and retrieval of video databases
- Innovation Project

**Outcomes:**

- Introduction to Display devices and their background
- Understanding and implementation of Transformation algorithms
- Basics of Ray Tracing and shading.
- Understanding the process of Camera and image formation and implementation
- Introduction to Computer and machine vision and its applications such as in Object recognition, Motion analysis.
- Practical understating of 2D and 3D transformation modelling
- Learning the basics of the Animations and Motion Pictures
- Understanding the Virtual Augmentation applications in security, medicine and manufacturing
- Basics of video databases and understating indexing and retrieval of video.

**References:**


1. *Watt, Alan*, 3D Computer Graphics. Addison-Wesley, 1999.
2. *Shirley, Peter, Michael Ashikhmin, Steve Marschner*, Fundamentals of Computer Graphics. 3rd ed. A K Peters/CRC Press, 2009.
3. *The Illusion of Life – Disney Animations*, Frank Thomas, Ollie Johnston, Walt Disney, 1981
4. *Computer Graphics, C Version*, 2nd Edition, Hearn & Baker, Pearson Education, 1997
5. *Computer Graphics: Principles and Practice in C*, 2nd Edition, J. Foley, Addison Wesley, 1995


**V.3 Computer and Brain: Knowledge Discovery and Artificial Intelligence [Theory] [Semester V] [3 – 0 – 2]**

Introduction Artificial Intelligence (AI) Concepts – AI Techniques – Intelligent program and agents – Problem Solving basics – issues in design of Intelligent search algorithm– Heuristic search techniques – Game Playing – Knowledge Representation-Rule based Systems – Structured Knowledge Representation – Semantic Nets – Fundamental and concepts of Programming languages like Prolog or Lisp – Languages and Knowledge Representation – Expert Systems – Domain Knowledge – Knowledge Acquisition – Case Studies – Computer Vision.

**Engineering Kitchen Activity [Laboratory]**

- Hands on experiment with Intelligent Systems.
- Hands on experiments with Problem Solving basics.
- Hands on implementation with Knowledge Representation.
- Hands on experiments with Prolog or Lisp.
- Hands on experiments for Computer Vision techniques.
- Innovation Project.

**Outcomes:** Upon Completion of this course the student will be able to:

- List the objectives and functions of modern Artificial Intelligence.
- Categorize an AI problem based on its characteristics and its constraints.
- Understand and implement search and adversarial (game) algorithms.
- Understand mathematical models such as belief networks and apply them to a range of AI problems.

- Have a glance at machine learning algorithms and extracting knowledge models from data.
- Learn different logic formalisms and decision taking in planning problems.
- Learn how to analyse the complexity of a given problem and come with suitable optimizations.
- Demonstrate practical experience by implementing and experimenting with the learnt algorithms.
- Student will also have sufficient expertise in both the theory of machine learning and its application to data mining, so as to use these powerful techniques in a wide range of industrial contexts, for example, bioinformatics, electronic commerce, and finance.
- Learn to analyse research activities with the different applications to explore the different analytical tools.

**References:**


1. *Artificial Intelligence - Building Intelligent Systems, 1st Edition*. P. Joshi & P. Kulkarni, PHI Learning, 2015.
2. *Artificial Intelligence, 3rd Edition.* R. *Elaine, K. Knight, S. Nair*, Tata McGraw-Hill, 2009.
3. *Winston, Patrick Henry*, Artificial Intelligence. 3rd ed. Addison-Wesley, 1992.
4. *Kevin P. Murphy and Robert R. Reitano*, Machine Learning: A Probabilistic Perspective, MIT Press, 2012.
5. *Artificial Intelligence and Soft Computing Behavioral and Cognitive Modeling of the Human Brain, Amit Konar,* CRC Press, 2000.


**V.4 History, culture & civilization [Theory] [Semester V] [2 – 0 – 0]**
(This is only a suggestive syllabus. There is no fixed syllabus for this unit)

The module has to be taught through projects and case studies by adopting information analysis, mathematical and technological insights associated with History, Culture and Civilization

Rebooting history and historical thoughts through technology, math and science perspective, Pre – Internet and Post - Internet analysis of civilization and culture demonstrated through case studies, Spatio-temporal aspects of culture and civilization.

**Outcomes:** History, culture and Civilization or Digital Humanities is a multidisciplinary field, undertaking project based paper at the intersection of digital technologies and humanities. Upon completion of the course the students would be able to-

- Develop preliminary models to deals with the issues connected to humanities disciplines and computer science and its allied technologies.
- Understand the impact of these techniques on cultural heritage, libraries, archives, and digital culture.
- Deal with contemporary issues on the impact of digital technology on socio-economic structure.

**Suggestive Reading**


1. *Digital_Humanities*, Anne Burdick, Johanna Drucker, Peter Lunenfeld, Todd Presner, Jefferey Schnapp, MIT Press, 2012
2. *Snap to Grid*, Peter Lunenfeld, MIT Press, 2001

**V.5.1 Maximizing performance: Human Resource management and Organizational\ Behavior [Theory] [Semester V] [3 – 1 – 0]**

Evolution of the concept of HRM - HR policies, functions and roles – Leadership – Recruitment – Training - Performance & potential appraisal - Statutory laws - Individual & Group Behavior- Leadership & power- Dynamics of Organizational Behavior- Human resource information system.

**Outcomes:**

- Learn to the rationality of evolution of management thought
- Discuss how to strategically plan for the human resources needed to meet organizational goals and objectives.
- Define the process of job analysis and discuss its importance as a foundation for human resource management practice.
- Steps required to develop and evaluate an employee training program.
- Know the activities involved in evaluating and managing employee performance.
- Able to explain how legislation impacts human resource management practice.
- Identify and describe the context in which unions and employers meet to organize, bargain, and resolve disputes.

**References**


1. *Organisational Behavior*, Stephen P. Robins, PHI Learning / Pearson Education, 15th Edition, 2012.
2. *Organisational Behavior*, Fred Luthans, McGraw Hill, 12th Edition, 2005.
3. *Organizational behaviour: Text and Cases,* K. Singh, New Delhi: Pearson education, 2009.
4. *Fundamentals of human resource management,* D. A. DeCenzo, & S. P. Robbins, New York: John Wiley & Sons, 9th Edition 2010.
5. *Industrial relations in India*, R. Sen, New Delhi: Macmillan India, 2nd Edition, 2009.


**V.5.2 Embedded systems studio - I [Theory + Practical] [Semester V] [3 – 0 – 2]**

Microcontroller and Microprocessor – Introduction to RTOS, VHDL, FPGA - Embedded system development (Memory, Interfaces, Peripheral devices, Sensors) – Basic RISC – CISC – I/O Ports – Instructions Sets – Addressing Modes – Clock System - Timers & Counters – Interrupts – ADC- DAC – Assembly Language & Embedded C – Pipeline – ARM & Thumb Instruction Set - Networking for embedded systems – Introduction to robotics and control – Actuators and Drives – Kinematics - Constraints – Position analysis – Redundant robot manipulators – Dynamic analysis of robot manipulators and mobile robots – Trajectory planning – Motion control - Sensors and Navigation - Internet of Things

**Engineering Kitchen Activity [Laboratory]**

- Design and rapid prototyping of embedded system using FPGA
- VHDL and RTOS implementation
- Study and implementation of networking protocols
- Networking using Internet of Things
- Design and fabrication of robots
- Path planning and navigation for robots

**Outcomes:**

- Understand the different type of microcontroller and microprocessor
- Programing based on assembly language
- Interfacing of microprocessor with microcontroller
- Application of microcontroller and microprocessor in real time system

## References


1. *Embedded System Design* – Santanu Chattopadhyay, PHI Learning, 2013
2. *Embedded System*– Raj Kamal, TMH, 2008
3. *Robotics: Modeling, Planning and Control,* B. Siciliano, L. Sciavicco, L. Villani and G. Oriolo, Springer, 2009.
4. *Introduction to Robotics: Mechanics and Control*, J. J. Craig, Pearson, 2005.


### V.5.3 Biological Instrumentation Kitchen: Genomics and Proteomics [Practical] [Semester V] [0-0-8]

- Isolation and analysis of plasmids
- Expression of proteins as inclusion bodies
- Isolation and refolding of the inclusion bodies
- Agarose Gel Electrophoresis
- SDS PAGE analysis
- Primer design
- Polymerase Chain Reaction (PCR)
- Restriction Digestion
- Cloning Strategy (Introductory Gene Cloning)

**Outcomes:** Engineering kitchen being an integral part of Systems Biology, this laboratory module gives an opportunity to the students to relate all the studied theoretical concepts with the experiments. The experiments in this course will help students to understand the basic Biochemistry, Molecular and Systems Biology as well as enable them to link the current fields of like Genomics, Proteomics and Bioinformatics.

## References


1. *Principles and Techniques of Biochemistry and Molecular Biology,* Wilson & Walker, Cambridge University Press, 2010
2. *Principles of Gene Manipulation and Genomics,* Primrose and Twyman, Wiley-Blackwell 2013


### V.6.1 Efficient manufacturing process: Production and Operations Management [Theory + Practical] [Semester V] [3 – 0 – 2]

Concept, Operations strategy, Management of Quality, Statistical Process Control, process Capability analysis and six sigma approach, concept and framework of Total quality management system, Elements and objective of supply chain management, inventory management: models and applications, Evaluation and Selection of appropriate Production and Operations technology, Computer Integrated Manufacturing Systems.

**Engineering Kitchen Activities [Laboratory]**

- Case study discussion on the company's productivity problem from the viewpoints of classical and modern organization theories and linking it with the real life problem.
- Case study discussion on the development of new production techniques which is being practiced in different sectors
- Creating live models which could be tested and used in companies linking mathematical models with the production techniques and strategies.

**Outcomes:**

- Demonstrate an awareness and an appreciation of the importance of the operations and supply management to the sustainability of an enterprise.
- Explain the importance of quality control.
- Apply techniques to measure quality control.
- Demonstrate a basic understanding of the problems of waiting lines.
- Demonstrate an understanding of the principles of just-in-time systems.
- Explain the importance of forecasting.
- Demonstrate the ability to apply some mathematical forecasting techniques.
- Demonstrate an understanding of the concept of aggregate planning.
- Demonstrate an understanding of the problems involved in inventory management.
- Demonstrate an understanding of the principles underlying materials requirements planning.
- Develop basic materials requirement schedules.
- Demonstrate an understanding of the concepts of operations scheduling.

**References**


1. *Production and Operations Management*, K. Aswathappa K and K. S. Bhat, Himalaya Publishing House, 6th Edition, 2010.
2. *Production and Operations Management*, R. Pannerselvam, Prentice Hall India, 3rd Edition, 2013.
3. *Operations Management*, N. Gaither and G. Frazier, South Western Cengage Learning, 2006.


**V.6.2 Signals & Systems Engineering [Theory + Practical] [Semester V] [3 – 0 – 2]**

Discrete-time systems - Continuous-time systems - Laplace transforms – Z transforms – Convolution – Frequency response – Fourier series and transform – Feedback – Sampling – Modulation – Filters design techniques

**Engineering Kitchen Activity [Laboratory]**

- Study of Convolution types.
- Computation of DFT & IDFT using DSP Processors
- FIR & IIR Filter Implementation using the DSP Processors.
- MATLAB implementation of different signal types
- Sampling theorem and reconstruction of signal from its samples using natural sampling

**Outcomes:**

- Identify, understand and differentiate between discrete time system and continuous time system
- Application of mathematical tools – Laplace transform, Z transform and Fourier transform to various signals
- Implement different signal types on MATLAB
- Design different types of filters
- Reconstruction of signal from its samples using natural sampling

**References**


1. *Oppenheim, Alan, and Alan Willsky*. Signals and Systems. 2nd ed. Prentice Hall, 1996.
2. *Haykin, S. and Van Been, B.*, "Signals and Systems" 2 Ed., John Wiley & Sons, 2003.


### V.6.3 Applied Genomics and Proteomics: Methods and techniques [Theory] [Semester V] [3-1-0]

Introduction to Recombinant DNA technology, cloning and expression vectors, Artificial chromosome, PCR and its types, expression and purification of heterologous proteins, DNA and Protein sequencing - Microarray - MALDI -RAPD - RFLP - *in situ* hybridization - Site directed mutagenesis - Gene transfer and gene therapy - Electrophoresis - Spectrometry - X-ray crystallography - NMR - Genomic and cDNA library - Two hybrid systems - Plant and Mammalian tissue culture.

**Outcomes:** This course is in sync with the Biological instrumentation Kitchen and the laboratory module is based on the theoretical component covered here.

- This course basically gears up all students for understanding the importance of all methods or techniques, which are utilized for relevant biological experiments.
- Characterizing techniques like Spectrometry, MALDI, NMR, X-ray crystallography are extremely important to understand, as all biomolecules like nucleic acids and proteins would have to be identified using them as one of the basic methods.
- Students are exposed to lot of biological concepts like gene cloning, recombinant DNA technology, DNA/ protein sequencing, genomic/ c-DNA library etc. which are obviously important, as these would be a prior knowledge before going in to more complex and upcoming branches like genomics, proteomics and bioinformatics.

**References**


1. *Principles and Techniques of Biochemistry and Molecular Biology,* Wilson & Walker, Cambridge University Press, 2010
2. *Principles of Gene Manipulation and Genomics,* Primrose and Twyman, Wiley-Blackwell 2013

## SEMSTER – VI

### VI.1 Linear Construction of Actions: Engineering through Linear Programming and Game Theory [Theory + Practical] [Semester VI] [3 – 0 – 2]

Formulation of Linear Programming Models - Theory of simplex method - optimality and unboundedness - the simplex algorithm - simplex method in tableau format - Computational efficiency of the technique - Introduction to artificial variables – two-phase method, Big-M method and their comparison - Formulation of the dual problem, Primal-dual relationships, Economic interpretation of the dual - Introduction to Post optimality analysis - Dual Simplex Method and its application - Formulation of the Transportation problem - Algorithm for solving transportation problem - Northwest - corner method, least cost method and Vogel approximation method for determining the starting basic solution - Assignment problem and its mathematical formulation,-Hungarian method for solving assignment problem - Formulation of two person zero sum games - Solving two person zero sum games - Games with mixed strategies - Graphical solution procedure -Linear programming solution of games

**Engineering Kitchen Activity [Laboratory]**

Program with Solver and its application to simple models

- Formulation of the model in Solver
- Solution of LPP with Solver
- Sensitivity analysis with Solver
- Solution of Transportation and Assignment problem with Solver
- Innovation Project

**Outcomes:** After completing this course, student should be able to

- Formulate linear programming models for given real situations
- Learn simplex method and its computational efficiency
- Formulate dual problems and understand economical interpretation of primal dual relationship
- Analyze post optimality and its economical interpretation
- Solve Transportation problems and assignment problems
- Learn some basic concepts of game theory
- Learn linear programming solution of games with mixed strategies

**References**


1. *Linear Programming and Network Flows,* Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, (2nd edition), John Wiley and Sons, India, 2004.
2. *Introduction to Operations Research,* F. S. Hillier and G. J. Lieberman, (9th Edition), Tata McGrawHill, Singapore, 2009.
3. *Operations Research, An Introduction,* Hamdy A. Taha, (8th edition), Prentice-Hall India, 2006.


### VI.2 Decoding Computation Structure and Logic [Theory] [Semester VI] [3 – 1 – 0]

Sets - Graphs - Digital abstraction - Automata - Combinatorial Logic - Randomness - Context free languages

**Outcomes:**

- Understanding of Sets and Graphs
- Understanding and implementation of Digital abstraction
- Philosophy of automata and machine
- Exposure to the Combinatorial Logic
- Critical analysis of Randomness
- Introduction to Context-free languages and their significance

**References:**


1. *Introduction to Automata Theory, Languages, and Computation*, John E. Hopcroft, Rajeev Motwani, Jeffrey D Ullman, 3rd Edition, 2013
2. *Introduction To Computer Theory*, Daniel I. A. Cohen, 2nd Edition, 2007
3. *Computation Structures*. Stephen Ward & Robert Halstead, MIT Electrical Engineering and Computer Science, 1989.
4. *Discrete computational structures*, Robert R. Korfhage, Academic Press, 1974


**VI.3 Internet and Web Technology [Theory + Practical] [Semester VI] [3 – 0 – 2]**

Web Technologies - HTTP, HTTPs, WWW, URL, Email, Domain Name Service, Web Browsers, Search Engines-Architecture, Crawlers, Type of crawlers, search tools; Chat & Bulletin Board Services, SNMP, VPN, VoIP & Internet Telephony. Security - Concept of Internet security, Firewall-Functioning, types of Firewall. Sniffing, spoofing, viruses, worms, Trojan horses, and their security. Cyber Laws - Introduction, The rights the various parties have with respect to creating, modifying, distributing, storing and copying digital data- concurrent responsibilities and potential liabilities. Web Design - Key issues in web site design, Use of Different HTML tags in web pages, Building HTML documents, Cascading Style Sheets-Internal, Inline and external style sheets, Javascript, Dynamic HTML with Javascript, Web programming, PHP, database connectivity with MySQL

**Engineering Kitchen Activity (Programming Software) [Laboratory]**

- Exercise based on developing websites and portals using HTML.
- Exercise based on developing websites and portals using CSS.
- Exercise based on developing websites and portals using Java Script.
- Projects based on PHP and MySQL to be implemented.
- Innovation Project

**Outcomes:**

- Acquire knowledge of web protocols and develop understanding of concepts of Internet security.
- Able to implement studied technologies in systematically developing a website with due regard to ethical and environmental issues.
- Understand the significance of emerging web technologies for the advancement of society.

**References:**


1. *Data Communication and Networking,* Forouzan, B.A., Tata McGraw-Hill. 2013
2. *Professional JAVA Server Programming,* Allamaraju and Buest, SPD Publication. 2007
3. *Internet and World Wide Web: How to Program,* 5th Edition, Deitel and Deitel, Pearson Education. 2008

### VI.4 Art & Design [Theory] [Semester VI] [2 – 0 – 0]

Exercises in design to understand principles of design - Distribution of space - Language of proportion and the process of form synthesis – Introduction to orthographic projections in simple positions – Drawing of plan, elevation and section of simple objects to scale, full size, reduced or enlarged – User interface and user experience design elements – Affective Computing in Interface Designs

**Outcomes:**

- Understanding of design thinking and innovation in product designing.
- How to do empathy research.
- Designing product brief and proof of concept.
- Prototyping.
- Product testing and validation

**References**


1. *Design Basics*, David Lauer, Stephen Pentak, Cengage Learning, 2011
2. *A Textbook of Geometrical drawing,* William Minifie, W.M. Minifie & Company, 1845 (Paperback reprinted in 2007)


### VI.5.1 Handling money: Finance management [Theory] [Semester VI] [3 – 1 – 0]

Basic Concepts of Finance, Investment decisions, financing and dividend decision, working capital management, long term sources of finance, strategic financing decisions, online Financial Management, Global financial information using Information Technology.

**Outcomes**

- Understand the basic principles of finance, their importance, and the importance of ethics and trust.
- Understand the mechanics behind valuation of money
- Discuss the difficulty encountered in finding profitable projects in competitive markets and the importance of the search.
- Determine whether a new project should be accepted or rejected using the payback period, the net present value, the profitability index, and the internal rate of return.
- Explain how the capital-budgeting decision help in deciding investment option
- Understand the relationships among operating, financial, and combined leverage.
- Discuss the concept of an optimal capital structure.
- Analyse the risk–return trade-off involved in managing working capital and net working capital.
- Understand and classified the sources of long term finances.
- Role of IT in disseminating information from financial market and institutions player.

**References**


1. *Financial Management*, V. K. Bhalla, New Delhi: Anmol Publications, 2009.
2. *Fundamentals of financial Management*, E. F. Brigham, & J. F. Houston, USA: Thomson, 11th Edition, 2007

3. *Financial management, Text, Problems and cases*, M. Y. Khan and P. K. Jain, Tata McGraw Hill, 5th Edition, 2008.
4. *Financial Management*, I. M. Pandey, Vikas Publishing House Pvt. Ltd., 10th Edition, 2007.

**VI.5.2 Embedded systems studio – II [Theory] [Semester VI] [3 – 1 – 0]**

VHDL Language - Concurrent and Sequential Assignment – Hardware specification - FPGA Architecture – Design of advanced robotic systems and embedded devices for varied applications – Virtual Reality and Computer Vision - Sensors Network: Wired and Wireless – Interfacing of various sensors –Vision Robotics – MEMS – Biomedical Sensors – Applications

**Outcomes:**

- Understand the hardware description language(VHDL)
- Application of VHDL on digital system design
- Interfacing the embedded devices with Robotics, MEMS etc.

**References**

1. *Asada, H., and J. J. Slotin*e. Robot Analysis and Control. New York, NY: Wiley, 1986
2. *Leslie Pack Kaelbling*. Learning in Embedded Systems. MIT Press, 2008

**VI.5.3 Biological Networks: from Micro to Macro Niche [Theory + Practical] [Semester VI] [3-0-2]**

Importance of pathways and networks in biological systems - Examples of networks from biological systems: ecological network, circulatory network, neurological network, metabolic network, cellular networks and gene regulation networks - Protein interaction networks - Inter and intra-cellular networks - Signal transduction in prokaryotes Regulatory pathway and components - Secretion systems in prokaryotes and eukaryotes Tree of life and macroevolution.

**Engineering Kitchen Activity [Laboratory]**

- Practical exposure to STRING and Cytoscape for building and analysis of protein and gene networks
- Microarray Analysis
- Building Ecological Models
- Neural Networks
- Energy calculations in complex ecological food webs
- Analysis of models related to gene regulation, epigenetic and other networks

**Outcomes:** After completion of this paper the students will have understanding from a macro level (interaction with the environment) to a micro-level (molecular network). The interaction of an individual with the environment through environmental networks, networks in within an organism such as neural and circulatory network, cellular network and molecular network. The students will also be equipped with

building and analysing gene and protein interaction networks which are now the most essential components of advanced Molecular Biology.

## References


1. *Molecular Biology of the Cell*, Alberts et al., Garland Science, 5 edition 2007.
2. *Molecular Cell Biology*, Lodish et al., W. H. Freeman & Company, 7 edition, 2012.
3. *Biochemistry & Molecular Biology of Plants*, Buchanan et al., Wiley-Blackwell 1 edition, 2002.
4. *Essentials of Ecology*, Begon, Howarth, Townsend et al., Wiley-Blackwell, 2014.


### VI.6.1 Business: Organization and Strategy [Theory + Practical] [Semester VI] [3 – 0 – 2]

Foundation of e-business and e-commerce, organizational models, role of Information Systems in Business, various approaches in ICT Systems, Emerging models in e-business, e-business and organizational changes, productivity and industries transformations, Perspectives and requirements for starting online business, Processes associated with managing website development ICT in B2B: Business models, revenues and sources, performance trends, e-business and organization management, Internet Marketing and e-Tailing.

Engineering Kitchen Activities [Laboratory]

- Case study discussion on real life cases of the companies that exploited the competitive advantage of IT to leverage their growth and expansion.
- Management quiz on the recent updates of the happenings in the e-business market scenario.
- Case study discussion on the development of new e-business which emerged out of market space and other concepts.

**Outcomes:**

- Understanding the current changing business environment
- Understanding the elements of Business models
- Indepth review and analysis of organisation and functioning of various categories of Business models based on transactions and Business entity
- Functions of e marketing and analysis of all e marketing techniques
- Theoretical framework of e- marketing planning and Web analytics through KPI's
- Awareness of Information systems being used at various managerial levels and across different sectors
- Detailed understanding of important strategic elements of e- SCM ,e-CRM ,e-procurement ,e-security
- Brief Introduction to Financial requirements for a start up and website management
- Creating awareness of change requirement and Understanding Evaluation parameters for e-Business.

## References


1. *Internet Business Models and Strategies: Text and Cases*, A. Afuah and C. L. Tucci, McGraw-Hill., 2003.
2. *Information Technology and the Corporation of the 1990s: Research Studies*, T. J. Allen and M. S. Morton, Oxford University Press, New York 1994.

3. *Strategies for e-Business: Creating Value through Electronic and Mobile Commerce*, T. Jelassi and A. Enders, Prentice Hall, 2005.
4. *Competitive Advantage: Creating and Sustaining Superior, Performance*, Michael E. Porter, The Free Press, New York, 1985.
5. *E-Learning Tools and Technologies*, Horton and Horton, Wiley Publishing, 2003.

### VI.6.2 Control Systems [Theory + Practical] [Semester VI] [3 – 0 – 2]

Introduction to Control Systems - Analysis and design objectives - The design process - Classification and modeling of control systems – Modeling in the frequency domain - Modeling in the time domain - Time response - Reduction of multiple subsystems - Signal flow graphs - Mason's rule. Stability - Routh Hurwitz Criterion - Steady state errors - Root locus techniques - Frequency Response Techniques - Design via state space –– Non-linear analysis – PID Controller and its applications

**Engineering Kitchen Activity [Laboratory]**

- Designing the model of a DC motor.
- Design of controllers for speed and position control
- Compensator design
- Circuit simulation
- State space model design.
- Design of temperature controller.
- Hands on experiments with PID controller
- Innovation Project

**Outcomes:**

- Able to understand the building blocks of basic and modern control systems.
- A good understanding of the concept of stability analysis of control systems in both time and frequency domain.
- A good understanding of the concept of MATLAB and SIMULINK toolbox to simulate the control systems.
- Learn how to use different controllers for a given problem.
- Able to perform comparative study of electrical systems using simulation software - Multisim, Eagle, LTSpice and experimental set-up.
- Understand the complex mathematical operations associated with building blocks of various control systems.

**References**

1. *Control Systems Engineering, 6th Edition*, Norman S Nise, Wiley, 2011.
2. *Linear Control Systems With MATLAB Applications, 11th Edition,* B. S. Manke, Khanna Publishers, 2013
3. *Discrete-Time Control Systems,* K. Ogata, Prentice Hall, 1995.
4. *Control Tutorials for MATLAB and Simulink,* W. Messner and D. Tilbury, Addison-Wesley, 1998.

### VI.6.3 Genes to Genomes [Theory + Practical] [Semester VI] [3-0-2]

Discovery of the gene concept - Mendelian and non-Mendelian inheritance - Gene interaction - Epistasis - Linkage and recombination - Population genetics and diseases - Genomes (Organization of pro and

eukaryotic Genome and importance of junk DNA, Characteristics, Genome mapping techniques, Genome evolution) - Epigenetics - Transposable elements - Coding and non-coding RNA - Gene expression.

**Engineering Kitchen Activity [Laboratory]**

- Punnett square, T-test
- Analysis of gene mapping
- Pedigree analysis
- Calculations to understand genome evolution
- Mathematical equations and models for prediction of epigenetic mechanism and inheritance

**Outcomes:** This paper deals with genetics and genome structures of various organisms. This is a unique paper where classical genetics is combined with modern genomics.

Upon completion of the course, the student will be able

- To understand Mendelian and non-Mendelian Genetics
- To create linkage map and to analyse pedigree chart
- To interpret epistasis and gene interactions at various levels
- To grasp epigenetics and population genetics
- To know the structural and functional aspect of genome and proteome

**References**


1. *Introduction to Genetic Analysis*, Griffiths et al., W H Freeman & Company, 10 edition, 2010.
2. *Genomes*, TA Brown, Garland Science, 3 edition, 2006.
3. *Molecular Biology of the Cell*, Alberts et al., Garland Science, 5 edition 2007.

## SEMSTER – VII

### VII.1 Algorithms for Computational Mathematics: Numerical Methods [Theory + Practical] [Semester VII] [3 – 0 – 2]

Solving Nonlinear Equations - Graphical method - Bracketing and Non-bracketing approach. - Bisection, Method of false position, Iterative method, Newton-Raphson method and Secant method - Errors and rate of convergence - Matrix notation of a system of linear equations - Gaussian elimination and Gauss-seidel method – Pivoting - Row-echelon form - LU factorization - Cholesky's method - ill-conditioning – norms - Solution of a system of nonlinear equations –Polynomial interpolation - Forward, Backward and Divided differences - Piecewise linear and Cubic Spline interpolation - Errors in interpolation - Newton-Cotes Integration Formula - Trapezoidal and Simpson's rules - Gaussian quadrature - error formulae - Euler, Modified Euler and Runge-Kutta methods for solution of differential equations - Power method, QR method, Gershgorin's theorem for Eigen Value problems

**Engineering Kitchen Activity [Laboratory]**

- Writing C/C++ programs for finding root of the equations using Bisection, Newton-Raphson, Iterative and Secant methods
- Writing C/C++ programs for solving system of linear equations
- Writing C/C++ programs for interpolation, forward, backward and divided difference
- Writing C/C++ programs for methods of numerical integration
- Writing C/C++ programs for Euler and Runge-Kutta methods

**Outcomes:** After completing this course, student should be able to;

- Understand the need of numerical techniques and their importance in real situations
- Learn different techniques of solving non-linear equations such as Bisection method, Newton Raphson method, Regula falsi method, Secant method & Iterative methods
- Analyze errors associated with these methods and their rate of convergence
- Learn Gauss elimination, Gauss seidel, LU decomposition methods for solving system of linear equations with pivoting concepts
- Learn polynomial interpolation, linear and cubic spline interpolations
- Analyze errors of interpolation
- Conceptualize numerical integration and errors associated with it
- Learn Euler's method and Runge-Kutta method for numerical solution of differential equations
- Write programs of all these numerical methods in C/C++

**References**


1. *Applied Numerical Analysis*, C. F. Gerald and P. O. Wheatly, Pearson Education India, 2007.
2. *Introduction to Applied Numerical Ananlysis,* R. W. Hamming, Dover Publications, 2012.
3. *Elementary Numerical Analysis- An Algorithmic Approach*, S. D. Conte and Carl de Boor, McGraw-Hill, 1980.
4. *Numerical Recipes: The Art of Scientific Computing*, 3rd Edition, William H. Press, Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery, Cambridge University Press, 2007

**VII.2 Software Engineering and Project Management [Theory + Practical] [Semester VII] [3 – 0 – 2]**

Introduction to software Engineering – Software Engineering Principles – Software metrics – Software development life-cycle – Software Process Models – Software Requirement Process –– System Design – Testing – Scheduling Estimation Models – Productivity Estimation – Cost Estimation – Schedule Estimation – Risk Management – Case Study.

**Engineering Kitchen Activity [Laboratory]**

- Analysis of a desktop/enterprise Software Applications under lens of software design fundamentals
- Requirement gathering, verification and specification of a new Software Project
- Creating Prototypes and outlines of problems in the frame of Software engineering aligned with design methodologies
- Reverse engineering management aspects any Open Source Software Project and identify Software
- Software Projects sign off with Project Charter and management of project plans
- Hands on Experiment on Requirement Management, Deliverable attributes of Software projects
- Design a Software Application, Product, and Service and integrate with existing system
- Estimation of Costing of Software, Time sheet management in estimation of Effort, Resource Management
- Design of User Guides, Software Manuals, Update Documentation, Release Guides, Deployment Guides, FAQs
- Basic Understanding on use of Agile & Scrum
- Innovation Project

**Outcomes:**

- Will have understanding of Software Engineering basics.
- Will have understanding of Software Process Models.
- Will have understanding of Software Requirement Process.
- Will have understanding of System Design.
- Will have understanding of Testing Approaches.
- Will have understanding of Scheduling Estimation.
- Will have understanding of Productivity Estimation.
- Will have understanding of Cost Estimation.
- Will have understanding of Risk Management.

**References:**


1. *Requirements Risks Can Drown Software Projects*, Leishman and Cook, Computer (November 2001).
2. *Software Engineering: A Look Back and A Path to the Future.* Leveson, Nancy, December 14, 1996. 3. Applied Software Project Management, Andrew Stallman & Jennifer Greene, O`Reilly, 2005.
3. *R . S. Pressman, "Software Engineering – A practitioner's approach",* 5th Ed., McGraw Hill Int. Ed., 2001.
4. *K. K. Aggarwal&Yogesh Singh, "Software Engineering",* 2nd Ed., New Age International, 2005.

**VII.3.1: Computer Language Design & Engineering [Theory] [Semester VII] [3 – 1 – 0]**

Micro programming - Function and structure of compilers – Lexical analyzer – Tokens – Parsing – Type system – Run time environment – Code generation and optimization – Intro Optimization – XML parser

**Outcomes:**

- Introduction to the compilers and their components
- Basics of language design and requirements
- Learning about several types of languages and their advantages and disadvantages
- Understanding various phases of the compiler and their practical implementation.
- Practical demonstration of tokenization, parsing and lexical analyses
- Understanding and implementation of the Runtime environment
- Learning about Code generation and code optimization using C, C++ or Java as an example.

**References:**


1. *Engineering a Compiler*, Cooper, K.D. and Torczon, L., MorganKaufmann. 2012
2. *Parsing Techniques: A Practical Guide*, Dick Grune, Ceriel J.H. Jacobs, Springer, 2007
3. *Compilers: Principles, Techniques and Tools*, by Aho, Sethi, Ullman, Addison-Wesley Pub Co, 1986.


**VII.3.2: Making Society Smart through Computational Social Systems [Theory] [Semester VII] [3 – 1 – 0]**

Media & Society – Social networks analysis – Digital Humanities – Technological Ethics – Privacy & Security – Human Dynamics – Urban planning – Transportation analysis – Financial & business analytics – Health analytics – Smart cities – Smart information systems – Governance.

**Engineering Kitchen Activity [Laboratory]**

- Projects for understanding Social networks.
- Projects for patterns analysis in Digital sociology.
- Projects on Privacy and Security aspects.
- Hands on experiments for Urban planning techniques.
- Projects on Intelligent transportation systems.
- Hands on experiments for problem solving in Smart Cities and Smart governance.
- Innovation Project.

**Outcomes:** The course will have following outcomes.

- Will have understanding of Social networks.
- Will have understanding of the important aspects of Digital humanities.
- Will have understanding of Privacy and Security related issues.
- Will have understanding of applying intelligent approaches for problems in Smart Cities.
- Will have understanding of Intelligent transportation systems.
- Will have understanding Information Systems and Smart governance.

**References**


1. *Bit by Bit: Social Research in the Digital Age*, Matthew Salganik, 2013
2. *Media and Society, Sixth Edition* Michael O'Shaughnessy, Jane Stadler, and Sarah Casey
3. *Digital Sociology*, Deborah Lupton, 2014

4. *Smart Sustainable Cities of the Future the Untapped Potential of Big Data Analytics and Context–Aware Computing for Advancing Sustainability*, Bibri, Simon Elias, 2018.

### VII.3.3: Introduction to Natural Language Processing [Theory] [Semester VII] [3 – 1 – 0]

Advanced concepts in NLP – Deep Learning Approaches – Simple Word Vector Representations- Advanced word vector representations – Named entity recognition – Introduction to TensorFlow- Language Modeling – Machine Translation – Parsing – Sentiment Analysis – Sentence Classification – Speech recognition – Machine Translation.

**Engineering Kitchen Activity [Laboratory]**

- Projects for understanding Natural language processing.
- Hands on experiments of Deep learning approaches.
- Hands on experiments for Sentiment analysis in Media.
- Hands on experiments for Speech recognition.
- Hands on experiments for Emotion recognition.
- Projects on Machine Translation.
- Innovation Project.

**Outcomes:**

1. Will have deep and advanced understanding of Natural Language Processing concepts.
2. Will have experiment level knowledge of Deep learning approaches.
3. Will have understanding of real world project on NLP in text, audio or video.
4. Will have understanding of NLP applications in Emotion recognition, Speech recognition, translation etc.

**References**


1. *Foundations of statistical natural language processing*, Manning, C. D., Manning, C. D., & Schütze, MIT press, 1999.
2. *Speech and language processing: An introduction to natural language processing. Computational linguistics, and speech recognition*, Jurafsky, D, 2010.
3. *Deep Learning (Adaptive Computation and Machine Learning),* Ian Goodfellow , Yoshua Bengio , Aaron Courville, Francis Bach, 2016.
4. *Deep Learning for Computer Vision with Python*, Adrian Rosebrock, 2018.


### VII.4 Visual arts & aesthetics [Theory] [Semester VII] [2 – 0 – 0]

Introduction to media art, computer art, digital art and interactive art - Aesthetic strategies in processual art - Art, technology and society - Interaction as aesthetic experience - Aesthetic of interaction in digital art - Aesthetic and new media - Interpreting visualizations : : Visualizing interpretations - Case studies

**Outcome:**

- Concept of art and aesthetics in communication.
- How to use art and aesthetic sensibilities in digital media technologies, advertisement, and communication.
- Practical case studies for skill enhancement.

- Learning integration of art and technology for real life experiences.

## References


1. *Aesthetics of Interaction in Digital Art*, Katja Kwastek, MIT Press, 2013
2. *Graphesis: Visual forms of knowledge production*, Johanna Drucker, Harvard University Press, 2014.
3. *SpecLab: Digital Aesthetics and Projects in Speculative Computing*, Johanna Drucker, University of Chicago Press, 2009


### VII.5.1 Environment Management [Theory] [Semester VII] [3 – 1 – 0]

Identification and evaluation of the environmental impacts of organization/product/service, Management of the environmental impacts of an organization, environmental auditing and environmental management systems – practical applications, Environmental management tools and techniques of sustainable development, Eco system Modeling, Environmental Information System.

**Outcomes:** This paper deals with various tools and techniques to assess environmental impacts caused by anthropogenic activities. Upon completion of the course the students would be able to-

- Have basic knowledge of satellite remote sensing and its application in environmental science.
- Have knowledge of Environmental Impact Assessment (EIA) & Environmental laws in India.
- Able to use Geospatial software (GIS).
- Able to prepare basic maps e.g., elevation, vegetation etc.
- Classify Land use and Land cover through satellite images.
- Assess urbanization through spectral band index.
- Able to quantify the complex environmental impacts through GIS.

## References


1. *Environmental Management: Principles and Practice* (Routledge Environmental Management Series), Chris Barrow, Routledge, 2003.
2. *Environmental Management in Organizations: The IEMA Handbook*, John Brady, Alison Ebbage and Ruth Lunn, Earthscan, Washington, DC., 2011.
3. *Essentials of Environmental Management*, Paul Hyde and Paul Reeve, IOSH Services Ltd. (U. K.), 2004.
4. *Textbook of Environmental Studies*, Erach Bharucha, UGC
5. *Fundamental Concepts in Environmental Studies*, D D Mishra, S Chand & Co Ltd


### VII.5.2 Engineering at Molecular Scale: Devices and Nanotechnology [Theory + Project] [Semester VII] [3 – 1 – 0]

Optical devices, electronic devices, liquid crystal and magnetic devices and their functionality- Spintronic devices (including spin valves and MRAM devices) - Nanoscale semiconductor electronic devices - CMOS at sub-15nm gate length, Carbon nanotubes, III-V and wide-bandgap devices - Devices for quantum computing -Nanoscale photonic devices - Basic properties of liquid crystals - Molecular properties of the organic materials and their use in current production and research level electronic devices - Thin Films Growth and Epitaxy, Characterization of Nanomaterials, Introduction to Sensor Technology - CMOS scaling challenges at nanoscale regimes - Device technologies for sub 100nm CMOS - Device scaling and ballistic MOSFET - Nanoscale CMOS design, Nanoscale circuits - Non classical CMOS.

**Outcomes:**

- For students, this course on devices and nanotechnology becomes very important, as this exposes them to the most versatile and interdisciplinary world of nanotechnology, which is emerging as a branch having its relevance in various fields like medical, biotechnological, industrial, forensic science, material science etc.
- Students would be exposed to the relevant concepts of nanomaterials, their identification and characterization along with studying their applications in optical, electronic and magnetic devices.
- Nano based devices and sensors are a major attraction for students, because this not only make them understand about the basic principles related to them, but it also inculcates the skills among students, which are required to developed nano-based formulations or devices as a whole.

## References


1. *Nanotechnology for Electronic Materials and Devices,* Korkin, A.; Gusev, E.; Labanowski, J.K.; Luryi, S. Springer, 2007
2. *Electronics Composite -Modeling, Characterization, Processing, and MEMS Applications*-Minoru Taya, Cambridge University Press, 2008
3. *Nanotechnologies for Future Mobile Devices* - Tapani Ryhänen, Mikko A. Uusitalo, Olli Ikkala, Asta Kärkkäinen, Cambridge University press, 2010
4. *High-Speed Heterostructure Devices From Device Concepts to Circuit Modeling* **-** Patrick Roblin, Hans Rohdin, Cambridge University press, 2006


### VII.5.3 Biodefense and Bioengineering [Theory + Tutorial] [Semester VII] [3-1-0]

Innate and acquired immunity - Passive and active immunity - T cell and B cell mediated immunity - antigen processing, antibody structure and classes - Emerging pathogens and host-pathogen interactions - Autoimmune diseases - Cancer and Tuberculosis- Secondary metabolites in plants - Innate immunity in insects and plants - Toll Receptors - Engineered single chain antibody - Techniques of biodefense such as RIA, ELISA, Immuno-fluoroscence - production and purification of monoclonal and polyclonal antibody and preparation of immuno-affinity columns – Immuno-diffusion - Rocket electrophoresis - Doping test - Pregnancy test.

**Outcomes:** After completion of this paper the students will have understanding about the immune system and its components. They will also have understanding about the diversity and capacity of the immune system to produce defense molecules against newly arising pathogens. They will also develop understanding about doping test, ELISA, pregnancy test etc. They will be conceptually equipped with techniques such as production of polyclonal and monoclonal antibody and antibody engineering.

## References


1. *Kuby Immunology*, Owen and Punt, W. H. Freeman & Company, 7 edition, 2013.
2. *Microbiology: an introduction*, Tortora et al., Benjamin Cummings, 11 edirtion 2012.
3. *Immunology and Immunotechnology*, Ashim K Chakravarty, , O.U. P, 1 edition, 2006.
4. *The Biology of Cancer*, Robert Weinberg, Garland Science

**VII.6.1 Business automation strategies ERP: Case studies and project in industry [Theory + Practical] [Semester VII] [3 – 0 – 2]**

Business Process modeling, Process Metrics, Overview of Enterprise systems and Business Processes, Identify and understand the functionalities in an ERP system, issues of ERP architecture, design development, Performance & Capabilities Gaps, Business Process mapping & redesign, , Advanced ERP modules, Industry specific case study, Project implementation.

**Outcomes:**

- Have a clear understanding of the Business Enterprise and it's processes
- Understanding of ERP system and its advantages
- Indepth analysis of various ERP modules
- Challenges of Integrating these modules with the Legacy systems
- Objectively envision various ERP implementation process
- Identify ERP Market Space in various sectors and verticals
- Detailed Analysis of Total cost of ownership of ERP.
- Understanding ERP architecture and Project teams
- Identify and measure different performance metrics for Processes
- Understanding organisational change management that should be accompanied for efficient implementation of ERP

**References**


1. *Bradford, M.* (2010). Modern ERP Systems: Select, Implement and Use Today's Advanced Business Systems. 2nd Edition, Lulu.
2. *Desai, S., Srivastava, A.* (2013). ERP to E²RP A case Study Approach. Eastern Economy Edition: PHI Learning Private Limited.
3. *Magal S.*, Word J. Essentials of Business Processes and Information Systems. Wiley.
4. *Sandoe K., Corbitt G., Boykin R.* (2001). Enterprise Integration. Wiley.


**VII.6.2 Circuit Analysis and Synthesis [Theory + Practical] [Semester VII] [3 – 0 – 2]**

Basic circuits analysis - Ohm's Law - Kirchoffs laws - DC and AC Circuits - Resistors in series and parallel circuits -Mesh current and node voltage method of analysis for D.C and A.C. circuits - Phasor Diagram - Power, Power Factor and Energy - Network reduction and network theorems for dc and ac circuits - voltage and current division, source transformation - star delta conversion - Thevenins and Nortons Theorem - Superposition Theorem - Maximum power transfer theorem - Reciprocity Theorem - Resonance and coupled circuits – Series, parallel resonance and their frequency response - Quality factor and Bandwidth - Self and mutual inductance - Coefficient of coupling - Tuned circuits - Single tuned circuits- Transient response for DC circuits - Transient response of RL, RC and RLC Circuits using Laplace transform for DC input and A.C. with sinusoidal input - Characterization of two port networks in terms of Z,Y and h parameters. Three phase circuits -Three phase balanced / unbalanced voltage sources - Analysis of three phase 3-wire and 4-wire circuits with star and delta connected loads, balanced & unbalanced - Phasor diagram of voltages and currents - power and power factor measurements in three phase circuits.

**Engineering Kitchen Activities [Laboratory]**

- Verification of nodal voltage and mesh current methods for solving circuits.
- Verification of important network theorems.
- Study of the response of the first order R-C and R-L circuits.
- Study of the response of a series and a parallel RLC circuits.

**Outcomes:**

- To understand difference between various types of electric circuits like DC and AC Circuits with Resistors in series and parallel and understanding related basic laws like Ohm's Law, Kirchhoff's laws
- To understand various circuit analysis methods like Mesh current and node voltage method of analysis for D.C and A.C. circuits, Network reduction and network theorems for dc and ac circuits , voltage and current division, source transformation, star delta conversion, Thevenins and Norton's Theorem, Superposition Theorem, Maximum power transfer theorem, Reciprocity Theorem
- To study resonance and coupled L, C, R circuits : Series, parallel resonance and their frequency response , Quality factor and Bandwidth, Self and mutual inductance, Coefficient of coupling ,Tuned circuits , Single tuned circuits- Transient response for DC circuits , Transient response of RL, RC and RLC Circuits using Laplace transform for DC input and A.C. with sinusoidal input
- To learn about characterization of two port networks in terms of Z,Y and h parameters.
- To familiarize students with Three phase circuits: Three phase balanced, unbalanced voltage sources, Analysis of three phase 3-wire and 4-wire circuits with star and delta connected loads, balanced & unbalanced Phasor diagram of voltages and currents, power and power factor measurements in three phase circuits.

**References**


1. *Linear circuits: analysis and synthesis* - Ayyagari Ramakalyan, Oxford University Press, 2005,
2. *Linear circuit analysis* - Chi Kong Tse, Addison-Wesley, 1998


**VII.6.3 Systems Biology [Theory + Practical] [Semester VII] [2-0-4]**

Biological complexity - Biological circuits - Bio-physical properties of macromolecules - Bio-molecular interaction analysis - Developmental biology - Data integration and hypothesis generation - Reversible reactions and feedback loops – Transient networks, Behavioral network - Cognitive and neural modelling - Memory and Learning - Neural models (vision, memory function, rhythm) - Synapse and networks – Neural plasticity and computational learning - Artificial intelligence - Neural imaging - Biological complexity, biological circits - Biophysical properties of macromolecules - Bio-molecular interaction analysis.

**Engineering Kitchen Activity [Laboratory]**

- Gene Regulation/Interaction networks models.
- Intercellular signalling network analysis.
- Creating biological databases and software.
- Small projects integrating different biological parameters.

**Outcomes:** After completion of this paper the students will have understanding about biological networks and organization of biological systems, designing simple organisms. They will be equipped to do perform biological data analysis, protein-protein interaction networks etc. This course will involve developing small projects integrating various database, software and streams of biological sciences

## References


1. *An Introduction to Systems Biology: Design Principles of Biological Circuits*, Uri Alon, Chapman & Hall
2. *Fundamentals of Computational Neuroscience*, Thomas Trappenberg, Oxford University edition, 2010.
3. *Handbook of Systems Biology: Concepts and Insights*, Marian Walhout, Marc Vidal, Job Dekker (Edited), Academic Press; 1 edition, 2012.