### International Institute of Information Technology, Hyderabad

School of Multi-disciplinary Computing

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**Dual Degree Programme - B.Tech in Computer Science and Master of Science in Computational Natural Sciences by Research**

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<th>Item</th>
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</thead>
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</tr>
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</table>
1. Vision and Mission for the School of Multi-disciplinary Computing

Vision
To be recognized as a globally reputed school by offering innovative academic programs and specializations in core computing, computing technologies, and computing in association with multiple disciplines, at all levels (UG, PG, Ph.D.) with state-of-the-art curricula, by promoting quality research in thrust areas, and blending research outcomes into teaching programs.

Mission Statements

MS1: To produce competent next-generation technology leaders, who can apply the science and engineering of computing to add immense value to their profession.

MS2: To implement a state-of-the-art curriculum in all the academic programs in line with the multidisciplinary societal and technological needs and encourage students to imbibe creativity, research, problem-solving skills, professional ethics, and human values.

MS3: To design and execute innovative multidisciplinary academic programs, specializations, and courses that combine computing and other domains organically, by involving all the stakeholders such as students, teachers, research scholars, experts from industry, academia, and alumni.

MS4: To conduct quality research in fundamental, applied, multidisciplinary, and futuristic domains and become a key player in the educational ecosystem within the country and abroad.

MS5: To create and sustain a strong suite of academic outreach programs catering to varied segments such as industry professionals, external students, and early career researchers.

MS6: To collaborate with other reputed institutions in India and abroad and implement best practices to achieve excellence.
2. PEOs, POs, and PSOs for the Dual Degree programme in Computational Natural Sciences

PROGRAM EDUCATIONAL OUTCOMES:

PEO 1: Demonstrate competency and creativity in some subareas of computer science so as to develop solutions and software systems for applications in natural sciences

PEO 2: Demonstrate requisite breadth and depth of knowledge in some subareas of natural sciences so as to excel in research and academic environments in these sub-areas

PEO 3: Exhibit communication skills and collaborative skills required to plan, participate effectively in multi-disciplinary teams.

PEO 4: Develop an aptitude for self-learning and life-long learning so as to keep abreast with rapid change in sciences and computing technology

PEO 5: Practice ethics and human values in their profession

Mapping between PEOs and Mission Statements

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<th>MS2</th>
<th>MS3</th>
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PROGRAM OBJECTIVES:

PO 1: Scientific Knowledge: Understand, train in and use concepts in varied disciplines including Sciences, Mathematics, Electronics and Computer Sciences to engineer and develop systems of varying scale.

PO 2: Problem Analysis: Identify, formulate and analyze complex scientific and engineering problems, reaching substantial conclusions using principles of Mathematics, Natural Sciences and Engineering Sciences
PO 3: Design/Development of Solutions: Identify and bring to fore the necessary concepts to arrive at solutions to problems in science that take into account the societal, cultural and ethical considerations.

PO 4: Conduct investigations of complex problems: interpolate and extrapolate based on existing knowledge base and self-learning skills to investigate the dynamics of complex problems and find solutions.

PO 5: Modern Tool usage: Demonstrate requisite hands-on skills to work with variety of software packages, libraries, programming languages, and software development environment tools useful in engineering large scale systems

PO 6: The engineer and society: Make judicious use of resources and understand the impact of technology across the societal, ethical, environmental and economic aspects.

PO 7: Environment and sustainability: Find scientific and technological solutions by considering the environmental impact for sustainable development

PO 8: Ethics: Practice principles of professional ethics and make informed decisions after a due impact analysis

PO 9: Individual and teamwork: Work efficiently in individual and team–oriented projects of varying size, cultural milieu, professional accomplishments, and technological backgrounds

PO 10: Communication: Effectively communicate and exchange ideas and solutions to any individual including peers, end-users and stakeholders

PO 11: Project management and Finance: Apply principles of project management in general and scientific project management

PO 12: Life-long learning: Exhibit the aptitude for independent, continuous and life-long learning required to meet their professional career goals.

PROGRAM SPECIFIC OUTCOMES:

PSO 1: Exhibit broad general knowledge in some sub-areas of computer science and engineering relevant to sciences such as: artificial intelligence, quantum computation and information theory

PSO 2: Exhibit broad general knowledge sub-areas of sciences such as condensed matter physics, bioinformatics, high energy physics, quantum computation

PSO 3: Demonstrate research skills to identify problems of sciences that can benefit from utilizing advanced techniques of Computer Sciences, and participate in work at the frontier of scientific research in such inter-disciplinary areas

PSO 4: Demonstrate knowledge and skills of required depth in at least one area of sciences and in computer sciences to excel in post-graduate and research programs as an inter-display bridge
Mapping between POs, PSOs and PEOs

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Curriculum

This dual degree program is designed to impart the young minds high-quality education both in computer science and in emerging areas in computational natural sciences and eventually to ‘Computational Thinking’ empowered research in natural sciences; primary goals are:

a. Providing state-of-the-art skills pertaining to the application of computers and computational sciences;
b. Enabling young students to carry out research activities in several new and emerging multidisciplinary areas in sciences across the boundaries of the traditional scientific disciplines, e.g., interface of biology and nano materials, fluid dynamics, material science, networks (biological, social, epidemiology, etc.), statistical mechanics, quantum mechanics/chemistry, structure function relationships of biological molecules, drug design, etc.; Special courses are designed to offer a multidisciplinary view in this broad research area. Students receive a basic training in all disciplines, and choose a specialization within one of these disciplines;
c. Providing an environment with coming together of computer and computational scientists with domain specialists, both theoretical as well as experimental

General Structure
With these goals in mind, the programme has the following structure:

- Core/foundational topics in math, and science domain, in addition to computer sciences are covered in the beginning four/five semesters
- Advanced courses in specific streams of interest (from the fifth year) and honors projects will lay the ground for research work
- Streams that are planned for this dual degree programme currently are:
  - Computational biology and Systems biology
  - Multi-scale modeling
  - Nanosciences
  - Quantum Physics
  - Computational Chemistry
- Thesis work on the selected problem start at the end of 8th semester.

The specific academic requirements for the program are as follows:

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<td>Probability and Random Processes</td>
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The remainder of the courses are electives and Honors projects:

1. Humanities electives: 2 courses (8 credits)
2. Computer Science electives: 4 courses (16 credits)
3. Science Domain electives: 5 courses (20 credits). Additional restriction is that THREE of the FIVE have to be in a PARTICULAR stream and remaining two can be in ANY of the other streams so as to enable student to prepare by taking advanced level courses in the thesis problem, while giving the choice to explore other streams.
4. Other electives: 2 to 8 credits
5. 1 unit (0 credits) of technical writing in the summer at the end of the 3rd year. This is to be registered in the 7th Semester.
6. 1 unit (0 credits) of research proposal by the end of 4th year. Register in 8th semester.
7. Must register for 24 Research thesis credits in the 9th and 10th semesters (at least 12 credits in a semester).

Honors projects – 4 courses (8 credits). Project courses enable students to gain practice in working on problems related to or leading directly to thesis work. These projects start after foundational courses in first four semesters, i.e. V, VI, VII and VIII semesters.
Choice Based Credit System:

The curriculum aims to continue the implementation of Choice Based Credit System with a minimal core program followed by electives from across disciplines including mathematics, sciences, human sciences, engineering electives, and so on. The curriculum set aside close to 17% of the credits necessarily from courses outside of the program so as to allow scope for students to credit courses from the sciences, mathematics, human sciences, and engineering sciences. A total of 12% credits are set aside as open electives – student can use these credits to either go deeper in the program or to opt for courses outside of the program and broaden their outlook by opting for multi-disciplinary courses too.

All courses use a continuous evaluation model with a combination of homework assignments, quiz exams, mid-term, and final examinations. Students are required to stay clear of plagiarism in any of their work submitted for evaluation. Most elective courses include a course project or a term paper additionally. These course projects often require students to practice team-work, enhance their self-learning and communication skills, and impart essential project management skills. Some courses include a laboratory component with a scheduled laboratory session.

For the highly motivates students, the present curriculum continues to provide the Honors option which requires students to do additional credits including projects and advanced electives and work under the supervision of a faculty member.

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<th>Course Name</th>
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Graduation Requirements for Dual Degree in CNS

In order to graduate with B.Tech Honours in Computer Science and Master of Science in Computational Natural Sciences by Research, a student must successfully complete 177 course credits and 24 Thesis credits according to the requirements stated in the curriculum handbook and meet the following requirements. The minimum CGPA required to graduate is 7.00 for MS or entire programme. Guidelines for the Honours program are provided at https://intranet.iiit.ac.in/offices/static/files/Honours-Guidelines-2022.pdf

Both the degrees (Bachelors and Master of Science by Research) are awarded together only after successful completion of the programme requirements.

- Must successfully complete SAVE (Sports, Arts, Value Education) credits in the 1st and 2nd years.
- Must successfully complete the programme Core.
- Must successfully complete 5 CNS electives in the 4th semester and beyond.
- Must successfully complete 5 CS electives in the 3rd and 4th years (not more than 1 in any semester).
- Must successfully complete 1 Humanities electives in the 3rd and 4th years (not more than 6 credits in any semester)
- Must successfully complete 2 courses (2 credits each) in Ethics in the 4th year.
- Must successfully complete 2 Open electives in the 3rd and 4th years (at least 1 each in semester and not more than 2 in any semester).
- Must successfully complete 8 Honours credits via 2 credits each in 4 semesters (5th to 8th).
- Must successfully complete 2 seminar credits in the 8th and 9th semesters.
- 1 unit (0 credits) of Technical writing workshop (OC4.101) in the summer at the end of the 3rd year. This is to be registered in the 7th Semester.
- 1 unit (0 credits) of Thesis proposal writing workshop (OC4.201) by the end of 4th year. Register in 8th semester.
- Must register for 24 Research thesis credits in the 9th and 10th semesters (at most 12 credits in a semester).
- Must successfully complete MS thesis evaluation process be including a public presentation and a Defense.
Course descriptions for Core & Elective Courses

Discrete Structures

Name of the Academic Program : B. Tech. in CSE
Course code : MA5.101
L-T-P : 3-1-0
Credits : 4
L= Lecture hours, T=Tutorial hours, P=Practical hours)

1. **Prerequisite Course / Knowledge:**
   Basic abstract algebra, High School Mathematics

2. **Course Outcomes (COs)**
   After completion of this course successfully, the students will be able to

   CO-1: Demonstrate critical thinking, analytical reasoning, and problem solving skills
   CO-2: Apply appropriate mathematical and probabilistic concepts and operations to interpret data and to solve problems
   CO-3: Identify a problem and analyze it in terms of its significant parts and the information needed to solve it
   CO-4: Formulate and evaluate possible solutions to problems, and select and defend the chosen solutions
   CO-5: Construct graphs and charts, interpret them, and draw appropriate conclusions
   CO-6: **Apply** the concepts of group theory, ring and field in various applications in computer science

3. **Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix**

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Note: Each Course Outcome (CO) may be mapped with one or more Program Outcomes (POs) and PSOs. Write ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low-level’ mapping

4. **Detailed Syllabus:**
• **Unit 1:** Sets, relations, functions, permutations, combinations. Applications to relations.


Cardinality of sets, finite and infinite sets, countable and uncountable sets, Cantors numbering.

• **Unit 2:** Group, subgroup/normal subgroup, homorphism/automorphism/isomorphism/eipmorphism, kernel, cosets, quotient group, product set in a group, center of a group, order/conjugate of an element, commutator.

Coding theory (Application to group theory).

• **Unit 3:** Ring, Field, Finite field over a prime. Applications to finite fields.

• **Unit 4:** Recurrence relations, generating functions, numeric functions. Applications to recurrence relations.

• **Unit 5:** Basics of probability theory, birthday attacks. Applications on hash functions.

• **Unit 6:** Graphs, Adjacency, Special Graphs, Isomorphic Graphs, Paths, Cycles and Circuits, Connected Graphs, Eulerian Graphs, Hamiltonian Graphs and Planar Graphs.

**Reference Books:**


5. **Teaching-Learning Strategies in brief (4 to 5 sentences):**

This course supports the expected characteristics, capabilities and skills for computer science graduates in the following ways:

- Mastery of Computer Science technical foundations
- Recognition of common Computer Science themes and principles
- Recognition of interplay between theory and practice
- Effective problem solving and critical thinking skills

6. **Assessment methods and weightages in brief (4 to 5 sentences):**

- Assignments: 10%
- In-Class Tests: 20%
- Mid Semester Examination: 30%
- End Semester Examination: 40%
Computer Programming

Name of the Academic Program : B.Tech in Computer Science and Engineering
Course Code : CS1.302
Title of the Course : Computer Programming
L-T-P : 3-1-3.
Credits : 5
(L = Lecture Hours, T = Tutorial Hours, P = Practical Hours)

1. Prerequisite Course / Knowledge:

Logical thinking and mathematical concepts at the level of a 10+2 standard student with a math major.

No prior programming experience or computing background is required.

2. Course Outcomes (COs)

After completion of this course successfully, the students will be able to:

CO-1: Explain the syntax of programming language constructs and their semantics and describe a program structure and its execution model. (Cognitive Level: Understand)

CO-2: Describe the steps in program editing, compilation and execution using tools such as Visual Studio Code, GCC compiler on a Linux/Windows/MAC operating system.

CO-3: Choose appropriate primitive data types and design new composite data types to model the relevant data in a given computation problem and also discover the algorithmic logic required to solve well-defined computational problems. (Cognitive Levels: Apply and Analyze)

CO-4: Compare and contrast the performance of different algorithmic approaches for simple computational problems with respect to time and memory. (Cognitive Levels: Analyze and Evaluate)

CO-5: Write programs involving basic dynamic data structures such as linked lists and use tools such as Valgrind to detect any memory leaks. (Cognitive Levels: Apply and Analyze)

CO-6: Use debugging tools such as GDB proficiently to rapidly isolate and remove subtle/complex bugs in programs. (Cognitive Levels: Apply and Analyze)
CO-7: Manage complex large projects using source code management tools such as GIT and build tools such as Make. (Cognitive Levels: Apply and Analyze)

CO-8: Assess and evaluate the solutions of their classmates through a peer review process (Cognitive Level: Evaluate)

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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4. Detailed Syllabus

- **Unit 1:**
  - Basic computer organization, Von Neumann architecture and stored program concept
  - High level programming languages, assemble code, binary instructions, compilers and assemblers
  - Programming editing, compilation and execution cycle

- **Unit 2:**
  - Use of variables as reference to memory locations
  - Basic data types and their representation
  - Operators and precedence levels, expressions
  - Writing straight-line sequence of code
  - Standard I/O Libraries

- **Unit 3:**
  - Conditional Statements (if-then-else) and Loops (for, while, etc.)
  - Arrays
  - Functions and parameter passing mechanisms
  - Standard libraries for string manipulation, disk file access etc.
  - Structures, Unions and Enumerations

- **Unit 4:**
  - Recursion
  - Program stack, scope and lifetime of variables
Pointers, heap memory, dynamic memory management, linked lists and memory leaks

- **Unit 5:**
  - Preprocessor directives
  - Source code management tools like GIT and use of GDB for program debugging
  - Multi-file programming and Makefiles

**Reference Books:**


**5. Teaching-Learning Strategies in brief**

Lectures are conducted in a highly interactive fashion. Programming problems are solved in-class along with students in a collaborative fashion. Sometimes two-three students are given an opportunity to present their programs to the class. At the end of every class, a small homework problem which helps in enhancing the concepts discussed in the class will be released. Students need not submit this homework. Tutorial sessions are used to teach the utilization of tools such as Visual Studio Code, GCC, GDB, GIT, Makefiles, perf, valgrind etc. Lab sessions are used to solve programming assignments and teaching assistants help students in developing program logic, debugging etc. on an individual basis. Faculty conducts office hours once in week. On the rest of the days, teaching assistants conduct office hours. This ensures continuous support to students. Key milestones are defined. Feedback from the students at those milestones are taken. The provided feedback is taken to fine tune the course and provide special support to students who are lagging behind. Five to six programming assignments are designed which gives an in-depth understanding of various concepts discussed in the class and their application to new problem scenarios along with proper analysis. Some problems involve evaluating, comparing and contrasting multiple solution approaches.

**6. Assessment methods and weightages in brief**

1. Programming Assignments (5 to 6) : 50 percent
2. Best 2 out of 3 Programming Lab Exam: $2 \times 15 = 30$ percent
3. Best 2 out of 3 Theory Exams: $2 \times 10 = 20$ percent

For programming assignments and lab exams, online judges such as DMOJ are used to provide immediate feedback to students. While some test cases are revealed, others are hidden. Partial marks are allocated for code peer-reviewing in programming assignments.

**Real Analysis**
1. Prerequisite Course / Knowledge:
Elementary knowledge of Calculus
Much of mathematics relies on our ability to be able to solve equations, if not in explicit exact forms, then at least in being able to establish the existence of solutions. To do this requires a knowledge of so-called "analysis", which in many respects is just Calculus in very general settings. The foundations for this work are commenced in Real Analysis, a course that develops this basic material in a systematic and rigorous manner in the context of real-valued functions of a real variable.

2. Course Outcomes (COs)
On successful completion of this course, students will be able to:
CO1. describe the fundamental properties of the real numbers that underpin the formal development of real analysis;

CO2. demonstrate the knowledge of an understanding of the theory of sequences and series

CO3. demonstrate skills in constructing rigorous mathematical arguments;

CO4. apply the theory in the course to solve a variety of problems at an appropriate level of difficulty;

CO5. demonstrate skills in communicating mathematics.

CO6: analyse how abstract ideas and regions methods in mathematical analysis can be applied to important practical problems.

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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4. Detailed Syllabus:

Unit 1 Sequence of real No, Bounded and Unbounded Sets, Supremum, Infimum, Limit points of a set, Closed Set, Countable and uncountable sets. Sequences, Limit points of a Sequence. Limits Inferior and Superior, Convergent sequence, Non convergent sequence, Cauchy General Principle of Convergence, bounded and monotone sequence, Infinite Series, Positive Term Series, Convergence of series of real numbers, Necessary condition, Absolute convergence and power series, Convergence tests for series.

(9 hours)

Unit 2 Mean value theorems (Rolle’s Theorem, Cauchy Mean Value Theorem, Lagrange’s Mean Value Theorem), Indeterminate forms, Taylors Series, Partial derivatives. Integration as a limit of a sum, Some integrable functions, Fundamental theorem of Calculus, Mean Value Theorems of Integral calculus, Integration by parts, Change of variable in an integral, Second Mean value theorem, Multiple integrals,

(9 hours)

Unit 3: Vector, Vector operations, Products, Areas and Determinants in 2D, Gradients, Curl and Divergence, Volumes and Determinants in space. Differential equations of first order and first degree. Linear ordinary differential equations of higher order with constant coefficients. Elements of Partial Differential Equation (PDE).

(7.5 hours)

Unit 4: Analytic function of complex variable, CR Equation, harmonic functions, Laplace equation, applications

(7.5 hours)

Unit 5 Integration of a function of a complex variable, M-L inequalities. Cauchy’s Integral Theorem. Cauchy’s Integral formula. Taylor’s and Laurent Expansion, Poles and Essential Singularities, Residues, Cauchy’s residue theorem, Simple contour integrals.

(9 hours)

- A project related to the above syllabus will be done by students to be submitted by the end of the semester.
References:


5. Teaching-Learning Strategies in brief:

Lectures in the classroom teaching, weekly tutorials involving problem solving and active learning by students and Project-based Learning

6. Assessment methods and weightages in brief:

Assignments in theory: 10 marks, Quizzes in theory: 10 marks, Mid Semester Examination in theory: 20 marks, End Semester Examination in Theory: 30 marks, Assessment project: 30 marks

**Digital Systems and Microcontrollers**
Name of the Academic Program: B.Tech in ECE
Course Code: S21EC2.101
Title of the Course: Digital Systems and Microcontrollers (DSM)
L-T-P: 3-1-3
Credits: 5
(L= Lecture hours, T=Tutorial hours, P=Practical hours)

1. Prerequisite Course / Knowledge:
Understanding of basic algebra concepts taught up to the 10+2 level

2. Course Outcomes (COs):
After completion of this course successfully, the students will be able to.
CO-1: Solve problems pertaining to the application of Boolean algebra, number systems, and simplification of logic expressions using Karnaugh maps.

CO-2: Develop a simplified combinational circuit as a solution for a given problem.

CO-3: Analyze a real-world problem to develop a digital design solution using sequential circuits to solve the problem.

CO-4: Describe the working of a basic 8-bit von Neumann architecture processor.

CO-5: Develop skills for simulating circuits using basic components on online simulation tools (example, Tinker CAD).

CO-6: Design, implement and test a given logic circuit using basic electronic components such as breadboards, ICs etc.

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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Note: 3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level mapping

4. Detailed Syllabus:
Unit 1: Number systems and interconversions (binary, decimal, hexadecimal), postulates of Boolean algebra, binary logic gates, binary functions
Unit 2: Simplification of binary expressions using K-maps, logic function implementation, combinational circuits
Unit 3: Latches and flip-flops, types of flip-flops, internal circuit design and operation
Unit 4: Sequential circuits, state diagrams, state tables, state equations, applications of sequential circuits
Unit 5: Registers and counters, memory and processor architecture

Reference Books:

5. Teaching-Learning Strategies in brief (4 to 5 sentences):
The course instruction is delivered through lectures with examples of real-world application of electronic systems to foster student understanding and interest. The course is structured as a theory and laboratory course, such that the concepts and circuits introduced in the theory classes can be experimentally applied and understood by the students. Assignments are designed to encourage students to critically think about the concepts discussed in the class and to learn to independently solve problems.

6. Assessment methods and weightages in brief (4 to 5 sentences):

Continuous evaluations:
Assignments – 10%
MCQ Quizzes – 20%
Lab reports – 20%

Comprehensive evaluations:
Lab exam – 15%
End semester exam in Theory – 35%

Title of the Course: Computing in Sciences-1
Name of the Faculty: Prabhakar Bhimalapuram
Name of the Academic Program CND
Course Code: SC4.101
L-T-P 3-1-0
Credits 2
1. Prerequisite Course / Knowledge:
Familiarity with running programs in BASH shell.

2. Course Outcomes (COs) (5 to 8 for a 3 or 4 credit course):
After completion of this course successfully, the students will be able to..
CO-1 Demonstrate understanding of basic concepts of molecular modelling

CO-2 Demonstrate the familiarity in operating prepackaged software commonly used in molecular mechanics, quantum chemistry, and visualization of molecular systems

CO-2 Compute (a) simple thermodynamic properties using quantum chemistry software for small molecules (b) thermodynamic properties using molecular dynamics software

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

|       | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO1 0 | PO1 1 | PO1 2 | PO1 3 | PO1 4 | PO2 1 | PO2 2 | PO2 3 | PO2 4 | PO3 1 | PO3 2 | PO3 3 | PO3 4 | PO4 1 | PO4 2 | PO4 3 | PO4 4 |
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| CO2   | 2   | 2   | 2   | 2   | 2   | 3   | 2   | 1   | 2   | 1     | 2     | 2     | 2     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| CO3   | 2   | 2   | 1   | 2   | 2   | 3   | 2   | 1   | 2   | 2     | 1     | 2     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| CO4   |     |     |     |     |     |     |     |     |     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| CO5   |     |     |     |     |     |     |     |     |     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| CO6   |     |     |     |     |     |     |     |     |     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| CO7   |     |     |     |     |     |     |     |     |     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |

Note: Each Course Outcome (CO) may be mapped with one or more Program Outcomes (POs) and PSOs. Write ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping

4. Detailed Syllabus:

Unit 1: Basic outline of application of quantum mechanics to molecule/s. Variational Theorem, and introduction to density functional theory. Basis sets. Geometry Optimisation and Frequency calculation. And other ‘simple’ properties from output of Quantum Chemistry software

Unit 2: Motivation for Classical mechanical models of molecules. Use of Newtonian equations of motion to model dynamics of molecular systems. Motivation for ergodic hypothesis, and calculation of thermodynamic properties.

Reference Books:

1. Molecular Modeling by Andrew Leach
2. Molecular Modeling for beginners by Alan Hinchcliffe
3. Software user manual for the following: GAUSSIAN, MOLDEN, NAMD and VMD.
5. Teaching-Learning Strategies in brief (4 to 5 sentences):
A lecture on a theory concept will be immediately followed by on-hands-practice using appropriate scientific software. Student will be encouraged to read carefully all the log files and become familiar with technical language, in addition to home work and assignments which will be mini-projects with specific task.

6. Assessment methods and weightages in brief (4 to 5 sentences):
The course will rely heavily on the submission of work done using scientific software like setting up input files, preparing initial molecular structures; this work will be in-class or tutorial submissions, homework etc.

Endsemester will carry 40% weightage of which 75% component will be based on demonstrating familiarity with scientific software taught in the course.

Home work and assignments will carry a weightage of 25%, while the in-class and tutorial submission will be another 10%. Finally, the remainder 15% will be theory part.

Value Education-1

Name of the Academic Program : B. Tech. in ECE, BTech in CSE
Course Code : OC3.101
Title of the Course : VALUE EDUCATION - I
L-T-P : 12-6-0 (Total number of hours)
Credits: 2
(L= Lecture hours, T=Tutorial hours, P=Practical hours)

1. Prerequisite Course / Knowledge: -NIL-

2. Course Outcomes (COs):

After completion of this course successfully, the students will be able to:

CO-1: Apply the basic framework of universal human values to the self.
CO-2: Look at larger issues that (for many reasons) most are not exposed to: social, political, community, family, individual, etc. in a sensitized way.
CO-3: Understand themselves and their own roles within the bigger context. What are really, truly important to them? What are made important by others?
CO-4: Engage and connect with others and nurture the relationships.
CO-5: Think to shape and change the world, and not be mere technologists or scientists.
3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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Note: ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping

4. Detailed Syllabus:

Unit 1: Goal in life - short term and long term goals; Basic aspirations - Happiness and Prosperity; Role of education and human conduct; Self-exploration; Developing a holistic view
Unit 2: Gratitude and the need to acknowledge one’s gratefulness; Understanding Self and Other;
Unit 3: Living in harmony at 4 levels: self-self, self-family, self-society, self-nature
Unit 4: Understanding needs of body and self; Right understanding of physical facilities and relationships; Understanding human relationships; Trust and Respect - the foundational values in relationships;
Unit 5: Harmony in Society; The sense of safety, justice and peace in society; Nature and Sustainability; Self-reliance and Gandhian thought

**Reference Books:**

5. Teaching-Learning Strategies in brief (4 to 5 sentences):
This is a discussed based course. The instructor shares information on a topic and guides the discussion in the class by asking the right questions. By keeping the objectives in mind, the instructor adopts different techniques including smaller group discussions, role-play/skit, use of video clips or images to analyse and some activities to keep the students engaged in class throughout. Talks by experts who made a difference are also organised for the batch. Field trips to farms, orphanages, old-age homes, villages and jails are arranged as part of the induction programme, in parallel to the classes in VE for the first year UG batch.

6. Assessment methods and weightages in brief (4 to 5 sentences):

This is a Pass/Fail course. The assessment methods include submissions of assignments and term papers. Critical thinking is expected from watching relevant short films or by reading assigned books. The classroom participation is also taken into consideration for evaluation. There are a few community-based activities and projects also. Participation in them is also important. (weightage for each kind of assessment may be given.)

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**Linear Algebra**

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**Prerequisite Course / Knowledge:**

This is one of the first math courses and only assumes school knowledge of maths.

**Course Outcomes (COs):**

After completion of this course successfully, the students will be able to...

**CO-1:** Explain the basic mathematical concepts like vector space, Basis, Linear Transformation, Rank Nullity Theorem, Matrix Representation of Linear Transformations, System of Equations, Determinants.

**CO-2:** Demonstrate familiarity with Eigenvalues, Eigenvectors, Orthogonality and Matrix Decomposition theorems.

**CO-3:** Synthesize proofs of theorems related to Matrices and Vector Spaces using clear mathematical and logical arguments.

**CO-4:** Apply principles of Spectral Decomposition and Singular Value Decompositions to real world problems in Image Compression, Principal Component Analysis etc.
CO-5: Design dimension reduction techniques with approximation guarantees using Best Fit Subspaces.
CO-6: Create mathematical models using principles of Linear Algebra and analyze them.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

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‘3’ for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping.

Detailed Syllabus:

Unit 1: Vector spaces, subspaces, Linear dependence, Span, Basis, Dimension, Finite dimension vector spaces Linear transformation, Range and Null space of linear transformation, Rank Nullity Theorem, Sylvester's Law, Matrix representation of a linear transformation for finite dimensional linear spaces, Matrix operations, change of basis, Rank of a Matrix, Range and Null Space of a matrix representing a linear transformation. Linear spaces with inner product [inner product example over space of functions: orthogonality and orthogonal functions in L_2.


Unit 3: Eigenvalues and Inner product: Eigenvalues & Eigenvectors, Norms, Inner Products and Projections, Applications like Analysis of Random Walks.

Unit 4: Advanced Topics: Spectral & Singular Value Decomposition Theorems, Applications of SVD and Best Fit Subspaces

Reference Books:

2. Finite Dimensional Vector Spaces, P. Halmos. , Publishers, Edition, Year

Teaching-Learning Strategies in brief (4 to 5 sentences):
Lectures will initially introduce the motivations, concepts, definitions along with simpler examples. This will be followed by assignments and quizzes that will make sure that the students have understood the concepts. These will be followed by deeper lectures and assignments which
lead the students to the bigger questions in the area. These will also be supplemented with real world engineering problems so that they can apply the concepts learned by them.

**Assessment methods and weightages in brief (4 to 5 sentences):**

- In-class Quizes: 15%
- Assignments: 15%
- Class Test 1: 10%
- Class Test 2: 10%
- Mid Semester Exam: 20%
- End Semester Exam: 30%

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**Title of the Course:** Classical Mechanics  
**Name of the Faculty:** Subhadip Mitra  
**Name of the Academic Program:** CND  
**Course Code:** SC1.102  
**L-T-P:** 3-1-0.  
**Credits:** 2  
(L= Lecture hours, T= Tutorial hours, P= Practical hours)

**1. Prerequisite Course / Knowledge:**  
None

**2. Course Outcomes (COs):**  
After completing this course successfully, the students will be able to

- **CO-1** Discover how symmetry is connected to the conservation laws and identify the symmetries of mechanical problems and select the suitable generalized coordinates.
- **CO-2** Solve basic mechanics problems using Lagrangian or Hamiltonian formulation  
- **CO-3** Explain the basic idea of special theory of relativity and compute simple problems involving length contraction and time dilation.

**3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix**

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Note: Each Course Outcome (CO) may be mapped with one or more Program Outcomes (POs) and PSOs. Write ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping

4. Detailed Syllabus:


Unit 2: Lagrangian formulation. Calculus of variations, Conserved quantities,

Unit 3: Central force motion. Conversion of a 2-body problem to c.m. and relative coordinates, elastic collisions, Rutherford scattering

Unit 4: Small oscillations & rigid body dynamics. Geometric description of mechanics, nonlinear oscillations

Unit 5: Hamiltonian formulation. Liouville Theorem. Virial Theorem

Unit 6: Special theory of relativity

Reference Books:

1. Classical Dynamics of Particles and Systems by S T Thornton and J B Marion
2. Course Of Theoretical Physics, Vol. 1 Mechanics by L D Landau & E M Lifshitz
3. Classical Mechanics by H Goldstein

5. Teaching-Learning Strategies in brief:

This is the basic course on Classical Mechanics. The focus would be on concepts and intuition building with reasonable stress on the underlying mathematical structure.

6. Assessment methods and weights in brief:

Assignments + Quizzes – (60%), Final exam (40%)
Credits: 2

(L= Lecture hours, T=Tutorial hours, P=Practical hours)

1. Prerequisite Course / Knowledge:

None

2. Course Outcomes (COs):

After completing this course successfully, the students will be able to

CO-1 Explain how to compute the notion of scalar and vector potentials and use them to compute electric and magnetic fields in various problems.

CO-2 Solve basic problems of finding electric and magnetic fields of configurations of charges/currents including dipoles in free space or in matter.

CO-3 Recognize the Maxwell’s equations and explain how they lead to electromagnetic waves in free space.

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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4. Detailed Syllabus:
Unit 1: Mathematical background. Basic vector calculus, orthogonal coordinate systems and Dirac delta function.

Unit 2: Electrostatics. Coulomb’s law, electric field, Gauss’s law, electric potential, electrostatic energy, conductors, electric fields in matter: polarization, bound charges, dielectrics

Unit 3: Magnetostatics. Lorentz force law, Bio-Savart law, Ampère’s law, vector potential, magnetic fields in matter: dia-/para-/ferro-magnets, bound currents

Unit 4: Electromotive force, Faraday’s law

Unit 5: Maxwell’s equations and electromagnetic waves

Reference Books:

1. Introduction to Electrodynamics by David J Griffiths
2. Classical Electrodynamics by J D Jackson
3. The Feynman Lectures on Physics, Volume II

5. Teaching-Learning Strategies in brief:

This is the basic course on Electrodynamics. The focus would be on concepts and intuition building with reasonable stress on the underlying mathematical structure.

6. Assessment methods and weights in brief:

Assignments + Quizzes – (60%), Final exam (40%)

Title of the Course : GENERAL AND STRUCTURAL CHEMISTRY
Name of the Faculty : Tapan K. Sau
Name of the Academic Program : CND
Course Code : SC2.101
L-T-P : 4-0-0
Credits : 4

1. Prerequisite Course / Knowledge: None

2. Course Outcomes (COs):

After completion of this course successfully, the students will be able to..

CO-1. Define quantum numbers for electrons, draw orbital diagrams, and state and apply the Pauli Exclusion Principle and Hund’s Rule to write the electronic configurations of atoms.

CO-2. Explain the position of elements in the periodic table and the general periodic trends in atomic size, ionic size, ionization energy, etc. of elements.
CO-3. State why chemical bonds form, identify the types of bonding that occur between metals/metal-nonmetal/nonmetal-nonmetal, state the current bonding models for simple inorganic and organic molecules, and predict important bonding parameters, structures, and properties.

CO-4. Compare the various acid-base theories, identify acid-base conjugate pairs, predict the strengths of acids and bases, and describe the properties of acids and bases.

CO-5. Apply bonding theories of coordination compounds to explain their optical and magnetic properties.

CO-6. Describe the properties and applications of various modern materials like semiconductors, superconductors, magnetic materials, polymers and composite materials, and nanomaterials.

CO-7. Distinguish intermediates and transition state; use chemical reaction theories to explain chemical reactions and their rates.

CO-8. Be able to describe how chemistry plays a central role in modern science.

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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Note: Each Course Outcome (CO) may be mapped with one or more Program Outcomes (POs) and PSOs. Write ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping.

4. Detailed Syllabus:

Unit 1. THE STRUCTURE OF ATOMS – A BASIC QM TREATMENT (2L)

Quantization of the energy levels; quantum numbers; s, p, d and f atomic orbitals; Pauli’s Exclusion Principle and Hund’s Rule of Maximum Multiplicity.

Unit 2. CHEMICAL PERIODICITY (2L)
Periodic classification of elements; Atomic Radius; Ionic Radius; Ionization Energy; Electron Affinity; Polarizability; The Inert-Pair Effect; Diagonal Relationships; Chemistry with emphasis on group relationship and gradation in properties (metals and non-metals; Main Group Elements (s and p blocks); Transition Metals (d block): 3d elements); Relativistic Effects.

**Unit 3. CHEMICAL BONDS, MOLECULAR GEOMETRY AND STRUCTURE (6L)**

a. Ionic Bond Formation and Lattice Energy  
b. Covalent Bonding; Valence-Bond Theory; Molecular Orbital Theory; How do we know that electrons are not paired; How do we know the energies of MOs? Major technique: XPS.  
c. Strengths and Lengths of a Bond; How do we know the length of a bond? How do we know the strength of a bond? Major techniques: Rotational & Vibrational Spectroscopies.  
d. VSEPR Model.  
e. ISOMERISM: Types; Optical isomerism in compounds (containing one and two asymmetric centers); Isomerism in coordination compounds; Major Techniques: Chromatography/Mass Spectroscopy

**Unit 4. COORDINATION COMPOUNDS (2L)**  
The Shapes of Complexes; The electronic structures of complexes: Crystal Field Theory; Ligand Field Theory; Color and magnetic properties; Major technique: UV-Vis Spectroscopy.

**Unit 5. SOLIDS AND MODERN MATERIALS (4L)**  
Solid structures; Bonding in the Solid State; Semiconductors; Superconductors; Luminescent Materials; Magnetic Materials; Composite Materials; Nanomaterials; Major Technique: XRD

**Unit 6. POLYMER MATERIALS: SYNTHETIC AND BIOLOGICAL (2L)**  
Synthetic Polymers: Synthesis of Organic Polymers; Electrically Conducting Polymers; Biological Polymers: Proteins and Nucleic Acids; Major Techniques: NMR & CD spectroscopy

**Unit 7. LIQUIDS (1L)**  
Intermolecular forces; Liquid structure; Liquid Crystals; Ionic Liquids

**Unit 8. PROPERTIES OF SOLUTIONS (2L)**  
Solubility and Common ion effect; Vapor Pressure; Colligative Properties; How to use colligative properties to determine the molar mass? The impact on biology and materials: Colloids; Biomimetic materials

**Unit 9. SOLUTION CHEMISTRY (2L)**  
Bronsted-Lowry Acids; Buffers; Polyprotic systems
Unit 10.  KINETICS (3L)

Mechanism of chemical reactions; Activated Complex Theory; Reactions in Solution; Reaction Dynamics; Enzymatic Catalysis

Reference Books:


5. Teaching-Learning Strategies in brief (4 to 5 sentences):

The course will involve lectures, exercises/assignments, quizzes, tutorials, and exams.

6. Assessment methods and weightages in brief (4 to 5 sentences):

The student assessment in the course involves written tests, quizzes, and assignments.

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Title of the Course : Computing in Sciences-2
Name of the Faculty : Prabhakar Bhimalapuram
Name of the Academic Program : CND
Course Code:
L-T-P : 3-1-0
Credits : 2

(L= Lecture hours, T=Tutorial hours,
P=Practical hours)

1. Prerequisite Course / Knowledge:

The course “Computing in Sciences-1” can be considered the paired-course; if the student has not done it before this course, it should be done after this course.

2. Course Outcomes (COs) (5 to 8 for a 3 or 4 credit course):

After completion of this course successfully, the students will be able to..

CO-1 Demonstrate skill of converting a word statement of a problem to a mathematical problem statement

CO-2 Formulate a solution by application of learned concepts (in other Math courses) and employ computer to solve the problem

CO-3 Demonstrate skills in computer visualization of data, solution.

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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4. Detailed Syllabus:

Unit 1: Introduction / review concepts in Python, data structures, flow control and modules NumPy, MatPlotLib, and SciPy

Unit 2: Simple integration of 1-d and 2-d functions. Adaptive grid scheme and monte carlo method.
Unit 3: Nonlinear dynamics of Logistic map: fixed point, bifurcation, period doubling, deterministic chaos.

Unit 4: Coin toss statistics, gaussian distribution, tails of distribution (Cramers Theorem)

Unit 5: Epicycles in 2-dimensions. Fourier analysis for characterization of periods and amplitudes of component circular motions.

Unit 6: Simple molecular dynamics of noble gases. Fixed temperature simulation using Langevin dynamics.

Reference Books:
2. https://www.learnpython.org/

5.Teaching-Learning Strategies in brief (4 to 5 sentences):
After going over the theory in the first lecture, the next two meetings (1 lecture and 1 tutorial) will be hands on practice, after which student will hand in the submission for that Unit. Students are encouraged to form small groups and work through the computer programming and solving the problems.

6.Assessment methods and weightages in brief (4 to 5 sentences):
Each unit will have a submission of a workbook. All submissions will be given equal weightage and will have a weightage of 75% of the grade. An endsem will be conducted which will have one problem, and will have a weightage of 25%; the problem will be chosen to have (a) graphical visualisation, (b) use of one or more scientific modules in python and (c) some amount of theory covered in the lectures.

Data Structures and Algorithms

Name of the Academic Program : B.Tech in Computer Science and Engineering
Title of the Course : Data Structures and Algorithms
L-T-P : 3-1.5-3.
Credits : 4
(L = Lecture Hours, T = Tutorial Hours, P = Practical Hours)

1. Prerequisite Course / Knowledge:
CS1.302 - Computer Programming

2. Course Outcomes (COs)
After completion of this course successfully, the students will be able to:
CO-1: Explain the design and implementation details of fundamental data structures and sorting/searching algorithms. (Cognitive Level: Understand)
CO-2: Write programs involving fundamental data structures and sorting/searching algorithms (Cognitive Levels: Apply and Analyze)
CO-3: Compare and contrast the performance of different data structures and sorting/searching algorithms with respect to time and memory. (Cognitive Levels: Analyze and Evaluate)
CO-4: Discover the algorithmic logic and new composite data structures required to solve well-defined computational problems while following specified compute constraints. (Cognitive Levels: Apply and Analyze)

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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4. Detailed Syllabus

- **Unit-1**
  - Recap: Array, Pointers, Structures, Asymptotic Complexity
  - Abstract Data Types
- **Unit-2: Linear Data Structures**
  - Linked Lists
  - Stacks
  - Queues
- **Unit-3: Non-linear Data Structures**
  - Binary Trees and Search Trees
  - Hash Tables, Sets, Maps
- **Unit-4: Sorting Algorithms**
  - Sorting – Insertion
  - Sorting – Selection, Merge, Quicksort
  - Heapsort
  - Counting Sorts
  - Radix Sort, External Sorting
  - Sorting – External, Selection Algorithms
  - Selection Algorithms
- **Unit-5: Graph Algorithms**
  - Graphs – Representation and Algorithms
  - Graphs – Representation and Algorithms (DFS, Dijkstra, Bellman)
  - Graphs – Representation and Algorithms (MST)
  - Graphs - Strongly Connected Components
- **Unit-6: Advanced Data Structures**
  - AVL Trees
  - Suffix Trees
Reference Books:
   1. Data Structures and Algorithm Analysis in C (M.A. Weiss), Pearson

5. Teaching-Learning Strategies in brief
Lectures are conducted in a highly interactive fashion. The design and implementation of data structures and sorting/searching algorithms is done as an in-class coding exercise. Tutorial sessions are used to teach the utilization of tools such as Visual Studio Code, Git etc. Lab sessions are used to solve programming assignments and teaching assistants help students in developing program logic, debugging etc. on an individual basis. Faculty conducts office hours once in week. Additionally, teaching assistants conduct office hours. This ensures continuous support to students. Five to six programming assignments are designed which gives an in-depth understanding of various concepts discussed in the class and their application to new problem scenarios along with proper analysis. Some problems involve evaluating, comparing multiple solution approaches.

6. Assessment methods and weightages in brief
   1. Programming Assignments (5): 40%
   2. Programming Lab Exam: 15%
   3. Best 2 out of 3 Theory Exams: 30%
   4. Mini Project (4 members per team): 15%

For programming assignments and lab exams, online judges such as DMOJ are used to provide immediate feedback to students. While some test cases are revealed, others are hidden. Partial marks are allocated for code peer-reviewing in programming assignments. For mini project, a presentation followed by a code-execution demonstration is used for evaluation.

Introduction to Software Systems

Name of the Academic Program : Bachelor of Technology in Computer Science and Engineering
Course Code : CSE
Title of the Course : Introduction to Software Systems
L-T-P : 1-0-3
Credits : 2
(L= Lecture hours, T=Tutorial hours, P=Practical hours)

Prerequisite Course / Knowledge: Not applicable.

2. Course Outcomes (COs)(5to8fora3or4creditcourse):

   After completion of this course successfully, the students will be able to…

   CO-1: Demonstrate familiarity with various OS Concepts, Shell programming, Web Technologies, Database Systems, Python Programming, and software engineering principles.

   CO-2: Explain the different types of tools and technologies that are suitable for solving different software problems

   CO-3: Apply tools and technologies to implement simple software solutions
3. **Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)–Course Articulation Matrix**

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Note: Each Course Outcome (CO) may be mapped with one or more Program Outcomes (POs) and PSOs. Write '3' in the box for ‘High-level’ mapping, 2 for ‘Medium-level mapping’, 1 for ‘Low’-level mapping.

4. **Detailed Syllabus:**

**Unit 1:** Software and Systems overview - SHELL: OS concepts, Kernel, Memory, Shell basics, Advance Linux commands including file management and schedulers, Control flows, Regex, Awk, 

**Unit 2:** Developing web applications - Introduction to HTML, CSS, and Javascript concepts, Datatypes, variables, operators, conditions, loops, functions, function expressions, events, form controls, data structures, javascript libraries, AFrame, Three.js

**Unit 3:** Programming with Python – Functions, Exceptions, Error Handling, Sequences, scoping rules, closures, higher-order functions, mutability, object model and inheritance, modules and packages, variable args, decorators, usage of libraries including SOAP and REST API, Flask based server set up.

**Unit 4:** SDLC and Databases – SDL Concepts, Version Control Systems, Editors, Bugtrackers, Basics of SQL, CRUD;

**Reference Material/Books:**

4. Workbook/Gitbook created by the course instructors ([https://serciit.gitbook.io/introduction-to-software-systems/](https://serciit.gitbook.io/introduction-to-software-systems/))

5. **Teaching-Learning Strategies in brief (4 to 5 sentences):**

The course is delivered using problem-based learning methodology. The major goal of the course is to introduce the students to various software and systems technologies and tools that can facilitate them to develop simple software systems. To achieve this goal, the course is delivered as a combination of lectures and tutorial sessions that provide students with hands-on experience in understanding the problem and implementing solutions using the corresponding software technologies and tools.
6. **Assessment methods and weightages in brief (4 to 5 sentences):**

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<tr>
<th>Assessment</th>
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<td>Mid Semester Exam</td>
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<td>End semester Exam</td>
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<td>Assignments (3)</td>
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<td>Labs (4 tests)</td>
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<td>Others (In-class Activities, Surprise quiz/test)</td>
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**Title of the Course**: Probability and Random Processes  
**Faculty Name**: Lalitha Vadlamani  
**Course**: ECE  
**Name of the Academic Program**: B. Tech in Electronics and Communication Engineering  
**Course Code**: MA6.102  
**L-T-P**: 3-1-0  
**Credits**: 4  
(L= Lecture hours, T=Tutorial hours, P=Practical hours)

1. **Prerequisite Course/Knowledge**: Basic idea of set theory, counting

2. **Course Outcomes (COs)**:  
   After completion of this course successfully, the students will be able to:
   - **CO1**: Describe the probability space associated with an experiment, conditional probability and Bayes theorem  
   - **CO2**: Give examples of discrete and continuous random variables and their distributions  
   - **CO3**: Calculate conditional and marginal distributions, distributions of functions of random variables, expectation and variance  
   - **CO4**: Analyze the properties of independent random variables, sums of random variables  
   - **CO5**: Interpret the tail bounds, law of large numbers and central limit theorem  
   - **CO6**: Evaluate the real world applications of random variables and random processes

3. **Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix**

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4. **Detailed Syllabus:**

**Unit 1:** Sets and set operations, Probability space, Conditional probability and Bayes theorem.

**Unit 2:** Discrete random variables, probability mass function, probability distribution function, example random variables and distributions, Continuous random variables, probability density function, probability distribution function, example distributions.

**Unit 3:** Joint distributions, functions of one and two random variables, expectation and variance, Conditional distribution, densities, conditional expectation, moment generating functions, characteristic functions.

**Unit 4:** Markov, Chebyshev and Chern off bounds. Random sequences and modes of convergence, Strong and weak laws of large numbers, central limit theorem.

**Unit 5:** Random processes, Mean and covariance functions, Stationary processes and wide-sense stationary processes, power spectral density, linear filtering of random processes.

**Reference Books:**


5. **Teaching-Learning Strategies in brief (4 to 5 sentences):**

The course has lectures supported by tutorials. In tutorials, problems related to the concepts presented in the class are solved by teaching assistants. Quizzes and group learning activities are conducted periodically so that students can actively engage with the course material.
assignment is given towards the end of the course, which requires the students to understand various applications of the theory and prepare a report.

6. **Assessment methods and weightages in brief (4 to 5 sentences):**

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<th>Type of Evaluation</th>
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<td>Quizzes and Viva</td>
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<td>Home Assignments</td>
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<td>Mid Semester Exam</td>
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<td>End Semester Exam</td>
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**Title of the Course:** Quantum Mechanics  
**Name of the Faculty:** Subhadip Mitra  
**Name of the Academic Program:** CND  
**Course Code:** SC1.203  
**L-T-P:** 3-1-0  
**Credits:** 4  
(L= Lecture hours, T=Tutorial hours, P=Practical hours)

1. **Prerequisite Course / Knowledge:**  
Basic linear algebra, complex numbers.

2. **Course Outcomes (COs):**

After completing this course successfully, the students will be able to

- **CO-1** Recognize the basic differences between the inherently probabilistic description in quantum mechanics with the deterministic description in the classical theories.
- **CO-2** Discover the role of linear algebra, complex analysis and probability theory in quantum mechanics and modern physics.
- **CO-3** Calculate and solve simple 1D quantum problems like particle in a box, the simple harmonic oscillator, and the free particle, etc.
- **CO-4** Apply their knowledge of basic problems in more complicated problems like the Hydrogen atom and discover advanced techniques.
- **CO-5** Recognize the conceptual challenges in quantum mechanics
3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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Note: Each Course Outcome (CO) may be mapped with one or more Program Outcomes (POs) and PSOs. Write ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping.

4. Detailed Syllabus:

Unit 1: Introduction: The Schrödinger equation and the uncertainty principle

Unit 2: Mathematical Formalism: Review of linear algebra, complex functions, Fourier transformation etc. and the generalized statistical interpretation, Heisenberg picture

Unit 3: Time independent Schrödinger equation: Infinite square well, harmonic oscillator, free particle, delta function potential, finite square well

Unit 4: 3D Problems: Spherical coordinates - Hydrogen atom, angular momentum, spin, two-particle systems, atoms

Unit 5: Advanced topics: Time independent perturbation theory, the variational principle, Bell’s theorem

Reference Books:

1. Introduction to Quantum Mechanics by David J Griffiths
2. Molecular Quantum Mechanics by P W Atkins and R S Friedman
3. Principles of Quantum Mechanics by R Shankar
4. Modern Quantum Mechanics by J J Sakurai
5. Quantum Physics by Stephen Gasiorowicz

5. Teaching-Learning Strategies in brief:

This is the first course on Quantum Mechanics. The students will see most of the topics for the first time. The focus would be on concepts and intuition building with reasonable stress on the mathematics of Quantum Mechanics.

6. Assessment methods and weightages in brief:

Assignments + Quizzes – (30%), Mid-term evaluation (30%), Final exam (40%)

Title of the Course : Introduction to Biology
Name of the Faculty : Vinod PK
Course Code:
L-T-P : 3-1-0
Credits : 4
(L= Lecture hours, T= Tutorial hours, P= Practical hours)
1. Prerequisite Course / Knowledge:
None
2. Course Outcomes (COs):
After completion of this course successfully, the students will be able to
CO-1: Identify levels of organization (in different time and length scales) in living organisms
CO-2: Describe the characteristics of living organisms
CO-3: Apply principles of physics to biology
CO-4: Distinguish different cellular and biomolecular structures and functions
CO-5: Explain different cellular and biochemical processes and their control
CO-6: Outline the applications of computers in biology
CO-7: Evaluate and synthesize information from the scientific literature
3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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4. Detailed Syllabus:

Unit 1: Cellular foundations: Cell organelles, Membranes and cellular compartments, Tree of life

Unit 2: Chemical foundations: Biomolecules, Structure and function

Unit 3: Physical foundations: Bioenergetics, Catalysis, Enzymes, Photosynthesis, Respiration

Unit 4: How cells obtain energy from the food - metabolism

Unit 5: Genetic foundations: DNA, Genes, chromosomes, Genomes, Mutations

Unit 6: Evolutionary foundations, Systematics

Unit 7: DNA Replication, Repair, and Recombination - an overview

Unit 8: How Cells Read the Genome: From DNA to Protein

Unit 9: Control of Gene expression

Unit 10: Cell Signalling, Cell cycle

Unit 11: Analysing and manipulating DNA

Unit 12: Introduction to sequencing and computational challenges
Reference Books:
1. Lehninger Principles of Biochemistry by David Nelson, Michael Cox
3. Fundamentals of Biochemistry by Voet, Voet& Pratt

5. Teaching-Learning Strategies in brief (4 to 5 sentences):

The topics are presented through examples of its applications (e.g., to human body, disease), of the latest research developments and of the history of the subject. Tutorials are designed to show how computers can be used to tackle biological problems. Evaluations test their ability to understand the relationships between topics and synthesize information from the scientific literature.

6. Assessment methods and weightages in brief (4 to 5 sentences):

- Assignments - 30%
- Review essay - 10%
- Quiz - 30%
- Exams - 30%

Title of the Course : Science Lab I
Name of the Faculty : Tapan K Sau, Prabhakar Bhimalapuram
Name of the Academic Program : Dual Degree CNS.
L-T-P : 0-0-3
Credits : 2
( L= Lecture hours, T=Tutorial hours, P=Practical hours)

1. Prerequisite Course / Knowledge:
None

2. Course Outcomes (COs):

After completion of this course successfully, the students will be able to

CO-1: Setup and perform optics experiments to measure properties of material like optical rotation, wavelength of monochromatic light etc

CO-2: Setup and perform chemistry experiments to measure properties like pH, concentration of chemicals and
CO-3: Perform physical measurements to measure properties like frequency of oscillator, young’s modulus etc.

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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Note: Each Course Outcome (CO) may be mapped with one or more Program Outcomes (POs) and PSOs. Write ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping

4. Detailed Syllabus:

1. Unit-1: Determination of the Specific Rotation of Sucrose and Composition of Sucrose Solution by a Polarimeter
2. Unit-2: Potentiometric Titration of a Mohr Salt Solution with Standard K2Cr2O7
3. Unit-3: Kinetic Study of the Decomposition of H2O2 in the Presence of FeCl3 Solution and the Effect of the Catalyst on the Rate Constant
4. Unit-4: Verification of the Beer-Lambert’s Law with a given solution and the determination of the concentration of a solution
5. Unit-5: Determination of pKa of a Weak Acid by pH-Metric Titration Method
6. Unit-6: Newtons Ring Method to measure Radius of Curvature of Plano-Convex Lens
7. Unit-7: Determination of Young’s Modulus of Material of a Beam by Method of Flexure
8. Unit-8: To determine the number of rulings per unit length of a diffraction grating
9. Unit-9: Stewart and Gee’s Method for Determining the Magnetic Field of the Earth
10. Unit-10: To Measure Slit-Width and the Separation between two Slits of Double Slit, by Observing Diffraction and Interference Fringes and to Compare them by Microscopic Measurement

Reference Books:

1. Introduction to Protein by Branden and Tooze
2. Fundamentals of Biochemistry by Voet, Voet and Pratt

5. Teaching-Learning Strategies in brief (4 to 5 sentences):
Course is a hands-on laboratory course requiring student to perform experiment after showing some prerequisite preparation. Then, the student’s setup of the experiment is checked, before allowing to proceed to experimental measurements. After completion of all measurements, student will perform required calculations for drawing the conclusions. Finally, a viva voice examination is conducted for the experiment to check a broad level knowledge of the experiment.

6. Assessment methods and weightages in brief (4 to 5 sentences):
Laboratory record - 40%
Quiz - 30%
Exams - 30%

Computer Systems Organization

Name of the Academic Program: B.Tech in Computer Science and Engineering
Course Code: CS2.201
Title of the Course: Computer Systems Organization
L-T-P: 3-1-0. Credits: 4

1. Prerequisite Course / Knowledge:

2. Course Outcomes (COs)
After completion of this course successfully, the students will be able to:

CO-1: Explain the Von Neumann Model of Computing. Describe all the steps involved in the execution of a program: composition, compilation, assembly, linking, loading and hardware interpretation of the program instructions. (Cognitive Level: Understand)

CO-2: Describe the instruction set architecture design principles. Show how programming language constructs can be mapped to sequences of assembly language instructions. Analyze and assess any given ISA. (Cognitive Levels: Analyze and Evaluate)
CO-3: Describe processor design architectural approaches. Compare and contrast sequential designs with pipelined designs. Propose new architectural approaches to optimize on performance and hardware costs (Cognitive Levels: Apply, Analyze and Create)

CO-4: Describe the basic functionality of an operating system. Clearly explain the system call interface, its design and implementation. Build systems akin to a bash shell, file server etc. using system calls. (Cognitive Levels: Understand and Apply)

CO-5: Describe the basics of process control and management. (Cognitive Levels: Understand and Apply)

CO-6: Describe the principles of virtual memory management. Analyze various memory management schemes for process isolation and physical memory utilization across multiple processes (Cognitive Levels: Understand, Apply and Analyze)

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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4. Detailed Syllabus

- **Unit 1:**
  - Basic computer organization, Von Neumann architecture and stored program concept
  - High level programming languages, assemble code, binary instructions, compilers and assemblers
  - Programming editing, compilation and execution cycle

- **Unit 2:**
  - Instruction Set Architecture Design Principles
  - CISC vs RISC ISAs
- Binary encoding of the instructions
- Mapping language constructs such as expressions, if-then-else statements, loops, functions to assembly code
- Machine representation of numbers

- **Unit 3:**
  - Processor design fundamentals
  - ALU Design
  - Single Cycle and Multi Cycle Processor Design
  - Pipelined Architectures
  - Hazards in Pipelined Architectures and approaches to resolve them.

- **Unit 4:**
  - Introduction to Operating Systems. Bootstrapping Process
  - System Calls, their design, implementation and application.

- **Unit 5:**
  - Process Control and Management
  - Scheduling multiple processes on multiple cores.
  - Basics of scheduling mechanisms and policies.

- **Unit 6:**
  - Physical vs Virtual Memory
  - Process and memory isolation/protection mechanisms
  - Virtual memory management
  - Page replacement algorithms

**Reference Books:**


**Teaching-Learning Strategies in brief**

Lectures are conducted in a highly interactive fashion. Use of various system tools such as compilers, assemblers, loaders, linkers, simulators etc. are demonstrated live in the class. Assignments include assembly language programming, digital system design exercises such as Arithmetic and Logic Unit Design, programming using system calls. Most of the ideas introduced in the class are emphasized through these assignments. Teaching Assistants and Faculty conduct office hours every day. Thus students have
continuous access to resources to get their doubts clarified and seek any extra help that is required. Sometimes students are encouraged to come to the board and explain the novel design ideas they came up with while solving assignments or mini-projects.

6. **Assessment methods and weightages in brief**

Programming Assignments (5 to 6) : 25 percent

1. Two Quizes: 2 x 10 percent
2. Mid Term: 20 percent
3. Final Exam: 35 percent

## Data and Applications

**Name of the Academic Program**: B.Tech. in Computer Science and Engineering

**Course Code**: CS4.301

**Title of the Course**: Data and Applications [Half]

**L-T-P**: 3-1-0.

**Credits**: 2

(L= Lecture hours, T=Tutorial hours, P=Practical hours)

1. **Prerequisite Course / Knowledge:**

Data Structures

2. **Course Outcomes (COs)**

After completion of this course successfully, the students will be able to –

CO-1. State data requirements for an application.
CO-2. Develop a conceptual model (such as, Entity Relationship Model and Diagram) for a set of data requirements.
CO-3: Comprehend relational data model and integrity constraints, and relational database design with normalization.
CO-4. Map the conceptual model to a relational data model and create and populate its corresponding relational database
CO-5. Map user queries into correct relational algebra, Structured Query Language (SQL), and tuple relational calculus expressions/statements. And updates using SQL.
CO-6. Implement an application to access, query and update a relational database.
3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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‘3’ in the box denotes ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level mapping

4. Detailed Syllabus:

Unit 1: Data, Database, Database System (3 hours)

Unit 2: Data models, Conceptual Data Modeling, ER Models (5 hours)

Unit 3: Relational Data Model, Relational Algebra, Tuple Relational Calculus (6 hours)

Unit 4: SQL, Constraints, Triggers, Database Connectivity, Applications (3 hours)

Unit 5: Normalization, Relational Database Design (4 hours)

- Four mini projects related to the above syllabus will be done by students.

References:


5. Teaching-Learning Strategies in brief:
Lectures by integrating ICT into classroom teaching, weekly tutorials involving problem solving and active learning by students and Project-based Learning by doing four mini-projects.

6. Assessment methods and weightages in brief:

Assignments in theory: 10 marks, Quizzes in theory: 10 marks, Mid Semester Examination in theory: 20 marks, End Semester Examination in Theory: 30 marks, Assessment of four mini projects: 30 marks

Automata Theory

Name of the Academic Program: B.Tech. in Computer Science and Engineering
Course Code : CS1.302
Title of the Course : Automata Theory
L-T-P : 3-1-0.
Credits : 2
(L= Lecture hours, T=Tutorial hours, P=Practical hours)

1. Prerequisite Course / Knowledge: Data structures, Elementary Formal Logic
2. Course Outcomes (COs)
   After completion of this course successfully, the students will be able to

   CO-1. Develop an understanding of the core concepts of Automata theory such as Deterministic Finite Automata, Non-deterministic Finite Automata, Regular Languages, Context Free Languages, Push down Automata, the basics of Turing Machines
   CO-2. Design grammars and automata for different languages
   CO-3. Identify formal language classes and prove language membership properties
   CO-4. Describe the limitations of the different computational models

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix
‘3’ in the box denotes ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping

4. **Detailed Syllabus:**

Unit 1: Introduction, Finite State Machines, Deterministic Finite Automata (DFA), Non deterministic Finite Automata (NFA), Equivalence of NFA and DFA, Regular Expressions, Regular Languages, Closure properties of regular languages, Pumping Lemma, Grammars, Left and Right-linear grammars

Unit 2: Context Free Grammar (CFG), Chomsky Normal Form, Push Down Automata (PDA), Equivalence of CFG and PDA, Context Free Languages (CFL), Deterministic PDA and Deterministic CFL, Pumping Lemma for context free languages

Unit 3: Introduction to Turing machines, Total Turing Machines, Recursive languages, Recursively enumerable languages, The Halting problem.

References:

5. **Teaching-Learning Strategies in brief:**

The lectures will be arranged in a manner that facilitates inter-student and faculty-student discussions. Additionally, the lectures will have small exercises that will ensure that the students actively participate in the learning activity and think out of the box. There will be more emphasis on ideas and reproduction of textbook material. There will be small homework problems that would help the student to re-engage with the essential components of the lecture.
Assignments will test the student’s ability to apply key concepts learnt, and also inform the faculty of the progress being made by the students in acquiring them.

6. **Assessment methods and weightages in brief:**

Homework: 25%
Quiz 1: 20%
Quiz 2: 20%
Final exam: 35%

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**Algorithm Analysis and Design**

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<tr>
<th><strong>Title of the course</strong></th>
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<tbody>
<tr>
<td><strong>Faculty Name</strong></td>
<td>Suryajith Chillara</td>
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(L - Lecture hours,
T-Tutorial hours, P - Practical hours)

**Semester, Year:** Monsoon 2022
(Ex: Spring, 2022)

**Name of the Program** B.Tech

**Pre-Requisites**
Discrete Mathematics, and Data Structures and Algorithms Course

**Outcomes**
After completion of this course successfully, the students will be able to...

CO-1: Demonstrate the ability to fully understand the analysis of various known algorithms.

CO-2: Identify problems where various algorithm design paradigms can possibly be applied.

CO-3: Understand the notions of computational intractability and learn how to cope with hardness.

CO-4: Understand the notion of approximation and randomized algorithms. If time permits, intro to quantum algorithms.

**Detailed syllabus:**
1. Basic graph algorithms
2. Greedy algorithms
3. Divide and Conquer
4. Dynamic Programming
5. Network flows
6. NP and computational intractibility
7. Intro to Approximation and Randomized algorithms
8. Intro to Quantum algorithms

Assessment method and Grading scheme:

- Deep quizzes 1 and 2: 10 + 10 = 20%
- Mid-semester exam = 20%
- End-semester exam = 30%
- In-class quizzes (unannounced) = 15%
- Assignments = 15%

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

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Each Course Outcome (CO) may be mapped with one or more Program Outcomes (POs). Write ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping

Teaching-Learning Strategies in brief (4-5 sentences):
The course lectures will include activities that promote the understanding of the lecture content by using small examples that students work out during the class itself and promote active and participatory learning. A good part of the lecture will involve problem solving and finding solutions to problems rather than expositing known material. In class tests that are held periodically are useful as summative assessments. Homework assignments are designed to reiterate the material covered in class lectures and also solve problems that are based on simple extensions of concepts described in the lectures.

**Design and Analysis of Software Systems**

**Name of the Academic Program:** Bachelor of Technology in Computer Science and Engineering

**Course Code**

**Title of the Course:** Design & Analysis of Software Systems

**L-T-P:** Credits: 4

( L= Lecture hours, T=Tutorial hours, P=Practical hours)

1. **Prerequisite Course / Knowledge:** Intro to Software Systems

2. **Course Outcomes (COs) (5 to 8 for a 3 or 4 credit course):**

   After completion of this course successfully, the students will be able to…

   CO-1: Understand the process of building software, through a live project

   CO-2: Inculcate software engineering knowledge, skills, and technologies needed to build software

   CO-3: Understand the structured approach and disciplined process (iterative) to develop software

   CO-4: Learn the steps in building a reasonably complex piece of usable that is maintainable

   CO-5: Enhance written and oral communication skills, needed for software engineering

3. **Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix**

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Note: Each Course Outcome (CO) may be mapped with one or more Program Outcomes (POs) and PSOs. Write ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping.

4. Detailed Syllabus:

The course will be run as units, following typical agile development sprints

1. Introduction
   a. Introduction to Software Engineering
   c. Project and Team Management - Project organization concepts (roles, tasks, work products),

2. Requirements
   a. Analysis and Specification),
   b. Estimation, Release Planning, Organizational activities (communication, status meetings).

3. Design
   a. Modelling (UML), Architecture and Design,
   b. System Decomposition, Software Architectural styles, Documenting Architectures,

4. Testing
   a. Quality Assurance - Unit, Integration, System and Acceptance Testing, Introduction to various testing techniques (e.g. Stress testing)

5. Design Patterns
   a. Design patterns, UI design
   b. Software Development for startups
Reference Books:


5. Teaching-Learning Strategies in brief (4 to 5 sentences):

The proposed course provides an introduction to software engineering concepts and techniques to undergraduate students using project based methodology. Students work in a small teams to deliver a software system that are proposed by real industrial clients. The course content and project introduces various software technologies, process and project management skills that are needed for the delivery of software in a team setting.

6. Assessment methods and weightages in brief (4 to 5 sentences):

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage (%)</th>
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<tbody>
<tr>
<td>Project</td>
<td>40</td>
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<tr>
<td>Client Feedback (R1 1% + R2 3%)</td>
<td>4</td>
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<tr>
<td>Coding Assignments (4)</td>
<td>20</td>
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<tr>
<td>Quizzes (Q1 + Q2, no midterm)</td>
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<td>Class submissions (3 Questions)</td>
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<td>End Exam/Research Paper</td>
<td>12</td>
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<td><strong>TOTAL</strong></td>
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</table>
CS Program Outcomes (POs)

PO1 Engineering knowledge: Use concepts from varied disciplines including Computer Science, Electronics, Mathematics, and the Sciences, to engineer and develop systems of varying scale.

PO2 Problem analysis: Identify, formulate and analyze complex engineering problems reaching substantial conclusions using first principles of Mathematics, Natural Sciences and Engineering Sciences.

PO3 Design/Development of solutions: Identify and bring to fore the necessary concepts from Computer Science and arrive at creative ways to solve problems that take into account the societal, cultural, and ethical considerations.

PO4 Conduct investigations of complex problems: Interpolate and extrapolate based on existing knowledge base and self-learning skills to investigate the dynamics of complex problems and find solutions.

PO5 Modern tool usage: Demonstrate requisite hands-on skills to work with a variety of software packages, libraries, programming languages, and software development environment tools useful in engineering large scale systems.

PO6 The engineer and society: Make judicious use of resources and understand the impact of technology across the societal, ethical, environmental, and economic aspects.

PO7 Environment and sustainability: Find technological solutions by considering the environmental impact for sustainable development.

PO8 Ethics: Practice principles of professional ethics and make informed decisions after a due impact analysis.

PO9 Individual and team work: Work efficiently in individual and team-oriented projects of varying size, cultural milieu, professional accomplishments, and technological backgrounds.

PO10 Communication: Effectively communicate and exchange ideas and solutions to any individual including peers, end-users, and other stakeholders.
PO11 Project management and Finance: Apply the principles of project management in general and software project management in particular with focus on issues such as the life cycle, scoping, costing, and development.

PO12 Life-long learning: Exhibit the aptitude for independent, continuous, and life-long learning required to meet their professional and career goals.

**Program Specific Outcomes (PSOs)**

PSO1 Exhibit specialized knowledge in some sub-areas of Computer Science and Engineering such as Theoretical Computer Science, Computer Systems, Artificial Intelligence, Cyber-physical Systems, Cyber-security and use this specialized knowledge base to solve advanced problems.

PSO2 Perform gap analysis in terms of systems and technologies and prepare roadmaps for incorporating state-of-the-art technology into system analysis, design, implementation, and performance.

PSO3 Demonstrate research and development skills needed to define, scope, develop, and market futuristic software systems and products.

PSO4 Demonstrate knowledge and skills at the required depth and breadth to excel in post-graduate and research programs.

---

**Machine, Data and Learning**

**Name of the Academic Program**: B.Tech. in Computer Science and Engineering  
**Course Code**:  
**Title of the Course**: Machine, Data and Learning  
**L-T-P**: 3-1-0  
**Credits**: 4  
(L= Lecture hours, T=Tutorial hours, P=Practical hours)

1. **Prerequisite Course / Knowledge:**
   
   Data Structures, Computer Programming

2. **Course Outcomes (COs)**

   After completion of this course successfully, the students will be able to:

   CO-1. Understand basic ML concepts such as Underfitting, Overfitting and Bias-Variance tradeoff  
   CO-2. Gain hands-on experience of applying these concepts to example problems  
   CO-3. Understand local search techniques with focus on Genetic algorithms  
   CO-4. Understand the basics of Probability and Utility theory  
   CO-5. Usage of these concepts in the context of formal models such as Decision theoretic models and Bayesian networks  
   CO-6. Understand Decision tree learning and notion of Information Gain

3. **Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program**
Specific Outcomes (PSOs) – Course Articulation Matrix

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</table>

‘3’ in the box denotes ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping

4. Detailed Syllabus:

Unit 1: Overview of AI and ML

Unit 2: Basic ML concepts including Data and generalization, Overfitting, Underfitting, Bias-variance tradeoff

Unit 3: Local Search Techniques, Genetic Algorithms
Unit 5: Basics of Probability and Utility Theory
Unit 6: Decision Theory, Markov Decision Process, Modeling observation errors

Unit 7: Decision Tree Learning, Construct decision trees from examples, Notion of information gain
Unit 8: Bayesian networks

References:
- Python ML by Example by Yuxi (Hayden) Liu, Packt Publishing, 2017
- Stuart Russell and Peter Norvig, Artificial Intelligence A Modern Approach, Pearson Education Inc., 2009

5. Teaching-Learning Strategies in brief:

The course lectures will cover the core concepts while assignments will provide ample scope to implement and understand many of the concepts in more detail. Learning of theoretical concepts and problem solving will be enabled via quizzes, mid and final exams.
6. Assessment methods and weightages in brief:

<table>
<thead>
<tr>
<th>Assignments</th>
<th>35 marks</th>
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<tbody>
<tr>
<td>Quizzes</td>
<td>15 marks</td>
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<td>Mid Exam</td>
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<td>End Exam</td>
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</table>

Title of the Course: Thermodynamics
Name of the Faculty: Harjinder Singh
Name of the Academic Program: B Tech (CND)
Course Code: SCI 204
L-T-P: 2(90mins)-1-0
Credits: 2
(L= Lecture hours, T= Tutorial hours, P= Practical hours)

1. Prerequisite Course / Knowledge: Basic (High school) physics/chemistry
2. Course Outcomes (COs) (5 to 8 for a 3 or 4 credit course):
   After completion of this course successfully, the students will be able to:
   CO-1 State principles and laws of Thermodynamics
   CO-2 Apply thermodynamics to investigate natural phenomena
   CO-3 Apply thermodynamic principles to allied disciplines like information processing.

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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Note: Each Course Outcome (CO) may be mapped with one or more Program Outcomes (POs) and PSOs. Write ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low-level’ mapping

4. Detailed Syllabus:
Unit 1: 1. Thermodynamic space, system and surroundings, variable, function, Thermodynamic process and energy transaction: Work, Heat; Walls: Diathermal, Adiabatic, (im)permeable 1L
2. Properties of Gases: Perfect and real: 1L
3. Zeroth law and temperature, first law and internal energy, enthalpy, thermochemistry, Hess’s law :1L
4. Expansion Work, Isothermal and Adiabatic Changes, Heat capacity :1L

Unit 2: 5. Second law and equivalence of different ways of stating it, Clausius inequality The Joule-Thomson Effect, Entropy, Heat Engine, Refrigerator, Carnot Cycle: 2L
6. Helmholtz and Gibbs Free Energies, thermodynamic equation of state, criteria for spontaneity, chemical potential, variation with temperature and pressure, Maxwell relations :2L
7. Fugacity and activity :1L

Unit 3: 8. Thermodynamics of mixing, Phase Diagrams and Phase Transitions: 2L
9. Chemical equilibrium, Equilibrium constant and standard free energy :1L
10: Equilibrium electrochemistry

Reference Books:

5. Teaching-Learning Strategies in brief (4 to 5 sentences):

Teaching currently is online. Along with prepared slides, tools are used to write material extempore and draw pictures to explain the material.
Class exercises are used to ensure effective learning.
Assignments are open for discussion before submission, though submission must be original.
Instructor is available 24X7 for discussions over the net either by a meeting or over email. This interactive process has helped the students to develop clarity on the learning material.

6. Assessment methods and weightages in brief (4 to 5 sentences):

<table>
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<tr>
<th>Quiz</th>
<th>25%</th>
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<tr>
<td>Final Exam</td>
<td>55%</td>
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<td>Assignments (4)</td>
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</table>

Title of the Course : Statistical Mechanics
Name of the Faculty : Harjinder Singh
Name of the Academic Program : B Tech (CND)
Course Code: SCI 205
L-T-P: 2(90mins)-1-0
Credits: 2
(L= Lecture hours, T=Tutorial hours, P=Practical hours)

1. Prerequisite Course / Knowledge: Thermodynamics, elementary classical and quantum mechanics

2. Course Outcomes (COs) (5 to 8 for a 3 or 4 credit course):
After completion of this course successfully, the students will be able to
CO-1 State principles of ensemble theory applied to statistical physics
CO-2 Apply statistical mechanics to investigate natural systems
CO-3 Apply scientific methodology to problems in allied disciplines.

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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Note: Each Course Outcome (CO) may be mapped with one or more Program Outcomes (POs) and PSOs. Write ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping

4. Detailed Syllabus:
Unit 1: 1. The purpose of statistics: Bridging the micro and the macro, random walk, binomial distribution and the Gaussian limit: 1L
2. Ensemble, micro-canonical, canonical and grand canonical; Partition function, Lagrange multiplier technique to obtain the Boltzmann distribution: 2L

Unit 2: 3. Statistical expressions for thermodynamic functions for monatomic, diatomic and polyatomic perfect gases, equilibrium constant using partition function: 2L
4. Classical statistical mechanics, Liouville equation, Equipartition of energy: 1L

Unit 3: 5. Identical particles, Quantum statistics - Fermi-Dirac and Bose-Einstein statistics: 2L
6. Special topics (Real gases, Liquids, Lattice dynamics, Ising spins, etc.): 3L

Reference Books:

5. **Teaching-Learning Strategies in brief (4 to 5 sentences):**
Teaching currently is on line. Along with prepared slides, tools are used to write material extempore and draw pictures to explain the material.
Assignments are open for discussion before submission, though submission must be original. Class exercises are used for effective learning.
Instructor is available 24X7 for discussions over the net either by a meeting or over email. This interactive process has helped the students to develop clarity on the learning material.

6. **Assessment methods and weightages in brief (4 to 5 sentences):**

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Weightage</th>
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<tbody>
<tr>
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<td>25%</td>
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<tr>
<td>Final Exam</td>
<td>55%</td>
</tr>
<tr>
<td>Assignments (4)</td>
<td>20%</td>
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</tbody>
</table>

Title of the Course : Biomolecular Structures
Name of the Faculty : Marimutu Krishnan
Name of the Academic Program : CND
Course Code : SC2.203
L-T-P : 3-1-0
Credits : 2

1. **Prerequisite Course / Knowledge:**
Basic thermodynamics, mathematics, and computing skills

2. **Course Outcomes (COs) (5 to 8 for a 3 or 4 credit course):**
After completion of this course successfully, the students will be able to

**CO-1** Describe how different building blocks of biomolecules assemble to form diverse biomolecular architectures that drive many biological processes

**CO-2** Familiarize with different types of biomolecular interactions and analyze how they contribute to the structural and thermodynamic stability of biomolecules and biomolecular complexes

**CO-3** Outline different experimental techniques commonly used to characterize the structure and dynamics of biomolecules

**CO-4** Interpret experimental binding affinity data using molecular thermodynamic and statistical principles
3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

<table>
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4. Detailed Syllabus:

Unit 1: Hierarchy of length and time scales in biological systems and processes

Unit 2: Biological macromolecules: proteins, nucleic acids, lipids, carbohydrates (The building blocks of these biomolecules and their chemical bonding and interactions will be discussed. The following topics will be covered in this module: different amino acids, their classification, dipeptides, conformations, different nucleotides, nucleobases)

Unit 3: Structure and properties of biomolecules: (Levels of protein structure: primary, secondary, tertiary and quaternary structures, Ramachandran plot, double helical structure of DNA, RNA structures, experimental techniques commonly used for analyzing structures and interactions including NMR, ESR, X-Ray, CD, Fluorescence)

Unit 4: Interactions between biomolecules (covalent and non-covalent interactions, base pairing, hydrogen bonding, salt bridges, hydrophobic interactions, solvation, protein--ligand, protein--protein, protein--nucleic acid interactions)

Unit 5: Thermodynamics of protein folding (entropic vs enthalpic factors), energy landscape, structural stability and mutations

Unit 6: Introduction to enzymes, enzyme catalysis, enzyme kinetics, Michaelis–Menten equation

Unit 7: Biomolecular assemblies: biomembranes, chromatin, molecular motors, cellulose, riboswitches

Unit 8: Molecular modeling and docking: concepts and techniques

Unit 9: Biomolecular databases and tools: protein data bank, nucleic acid databases

Unit 10: Dry lab: Models, visualization, calculation of structural properties

Reference Books:
1. Lehninger Principles of Biochemistry - D. L. Nelson and M. M. Cox
2. Biochemistry - L. Stryer et al

5. Teaching-Learning Strategies in brief (4 to 5 sentences):
6. **Assessment methods and weightages in brief (4 to 5 sentences):**
Quizzes (20%), Assignments (25%), Reading Projects (25%), Final Exam (30%)

---

**Title of the Course**: Organic Chemistry

**Name of the Faculty**: Bhaswar Ghosh

**Name of the Academic Program**: CND

**Course Code**: SC2.202

**L-T-P**: 3-1-0

(L= Lecture hours, T= Tutorial hours, P= Practical hours)

**Credits**: 2

1. **Prerequisite Course / Knowledge**: NA

2. **Course Outcomes (COs) (2 credit course)**:
   
   CO1: Explain various mechanisms of structural stability of organic compounds and their reactivities
   
   CO2: Apply the mechanisms to describe types of reactions using stability of reaction intermediates
   
   CO3: Analyze the outcomes of different organic reactions using the principles of structure and stability of reactants and intermediate compounds

3. **Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix**

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4. **Detailed syllabus**

   Concepts on structures, stabilities and reactivities

   Unit 1: Reactive intermediates: Formation, structure, stability and fate of various reactive intermediates (Carbanion, carboxcation, carbenes, nitrenes, benzynes, free radicals) – Reactive intermediates in biology and environment
Unit 2: Concepts of aromaticity
Unit 3: Molecular symmetry and chirality, Stereoisomerism, Classification of stereoisomerism, configuration, chiral centre, Axial chirality, planar chirality, helicity, Racemization and methods of optical resolution, Determination of configuration, Conformation of acyclic and monocyclic molecules-conformation and reactivity, Prochirality and prostereoisomerism, Stereochemistry of alkene, Chirality in molecules devoid of chiral centers, Chirooptical properties. Some reactions and their mechanisms
Unit 4: Methods for determining structures and reaction mechanisms
Unit 5: Types of reactions and their mechanisms Radical substitution Electrophilic addition to alkenes and alkynes – stereochemical considerations – Markonikov rule Nucleophilic Substitution at saturated carbons (SN1, SN2 and SNi): Types, stereochemical considerations, Role of solvent Nucleophilic addition to the Carbonyl group Elimination reactions: Types (E1, E2 and E1cB) - stereochemical consideration, Role of solvent Hofmann rules- Zaytsev Rules Nucleophilic substitution at the carbonyl group Electrophilic Aromatic Substitution: Benzene and its reaction with electrophiles- Effect of functional groups Nucleophilic Aromatic substitution: Diazonium compounds-benzyne mechanism Pericyclic reactions: Electrocyclic reactions, Cycloadditions, Sigmatropic rearrangements and Group transfer reactions Important name reactions involving rearrangements Functional group wise reactions Conversions and Identifications.

5. Teaching-Learning Strategies in brief (4 to 5 sentences):
The objective of the course is to familiarize the CND students with basic concepts of organic reaction mechanisms. Since organic reactions are wide spread in natural biological systems as well as their applications in various industries, understanding the mechanisms is crucial. The course would provide the students with tools to analyze outcomes of organic reactions. It will further help them to learn the numerical analysis of molecular reactions later.

6. Assessment methods and weightages in brief (4 to 5 sentences):
Assignments – (20%), Class Quizzes + Mid-term evaluation (40%), Final exam (40%)

Reference book
A Guidebook to Mechanism in Organic Chemistry by by Peter Sykes

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**Science Lab 2**

**Value Education-2**

**Name of the Academic Program** : B. Tech. in ECE, BTech in CSE  
**Course Code** : OC3.101  
**Title of the Course** : VALUE EDUCATION - 2  
**L-T-P** : 12-6-0 (Total hours)  
**Credits** : 2  
(L= Lecture hours, T=Tutorial hours, P=Practical hours)
1. **Prerequisite Course / Knowledge**: NIL

2. **Course Outcomes (COs)**:

   After completion of this course successfully, the students will be able to:
   
   CO-1: Apply the basic framework of universal human values to understand oneself
   
   CO-2: **Explain** the relation of self with family, society and nature
   
   CO-3: **Explain** the concept of living in harmony at all the levels
   
   CO-4: **Demonstrate the** right understanding of relationships and **Right utilization of physical facilities**
   
   CO-5: Realise the long-term goal of being happy and prosperous

3. **Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix**

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   Note: ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping

4. **Detailed Syllabus**:

   Unit 1: Revisiting goal in life - short term and long term goals; Basic aspirations - Happiness and Prosperity; Role of education and human conduct; Self-exploration; Developing a holistic view
   
   Unit 2: Self-reflection and reflecting on relationships; understanding value-based life
   
   Unit 3: Living in harmony at 4 levels: self-self, self-family, self-society, self-nature
   
   Unit 4: Harmony in Society; Broadening one’s perceptions;

   Unit 5: Nature and Sustainability; Our role in protecting Nature;

5. **Reference Books**:


6. **Teaching-Learning Strategies in brief (4 to 5 sentences)**: 

   [Teaching strategies content]
This is a discussed based course. The instructor shares information on a topic and guides the discussion in the class by asking the right questions. By keeping the objectives in mind, the instructor adopts different techniques including smaller group discussions, role-play/skit, use of video clips/films or images to analyse and some activities to keep the students engaged in class throughout. Talks by experts who made a difference are also organised for the batch.

6. Assessment methods and weightages in brief (4 to 5 sentences):

This is a Pass/Fail course. The assessment methods include submissions of assignments and term papers. Critical thinking is expected from watching relevant short films or by reading assigned books. The classroom participation is also taken into consideration for evaluation. There are a few community-based activities and projects also. Participation in them is also important.

Weightage for each kind of assessment may be given

### Operating Systems and Networks

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<th>Name of the Academic Program</th>
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(L= Lecture hours, T=Tutorial hours, P=Practical hours)

1. Prerequisite Course / Knowledge:

Programming languages, Digital Logic Design, Computer Organization

2. Course Outcomes (COs)

After completion of this course successfully, the students will be able to,

CO-1. Extend the concepts of layering and modularity to build new software systems

CO-2. Develop appropriate scheduling/synchronization/memory management/virtual memory/protection module for a new task-specific operating system.

CO-3: Implement an application on the top of given operating system in an efficient manner based on process and thread framework available in the given operating system.

CO-4. Architect the given system on the top of operating systems by exploiting the system calls of the given operating system services as far as possible.
CO-5. Develop a network-based application by exploiting networking related system calls.

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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Note ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level mapping

4. Detailed Syllabus:

Unit 1: Introduction, Process and thread management (9 hours);
Unit 2: CPU scheduling, Process Synchronization, Deadlocks (12 hours);
Unit 3: Memory management, Virtual memory (9 hours);
Unit 4: File systems, Protection and Security (6 hours);
Unit 5: Networking (9 hours);

- Five mini projects related to the above syllabus will be done by students in the laboratory

Reference Books:
1. Silberschatz, A, Galvin, P, Gagne, G. Operating system concepts, Addison-Wesley, 2018

5. Teaching-Learning Strategies in brief

Lectures by integrating ICT into classroom teaching, weekly tutorials involving problem solving and active learning by students and Project-based Learning by doing 5 mini-projects in laboratory by the students
6. Assessment methods and weightages in brief

Two Class Room tests: 10 marks; Mid Semester Examination in theory: 20 marks, End Semester Examination in Theory: 40 marks, Assessment of 5 mini projects in Laboratory: 30 marks

Title of the Course: Spectroscopy
Name of the Faculty: Marimutu Krishnan
Name of the Academic Program: CND
Course Code: SC2.304
L-T-P: 3-1-0
Credits: 2

1. Prerequisite Course / Knowledge:
Basic quantum mechanics and computing skills

2. Course Outcomes (COs) (5 to 8 for a 3 or 4 credit course):
After completion of this course successfully, the students will be able to

CO-1 Outline the basic principles of different spectroscopic techniques
CO-2 Analyze electronic, vibrational, and rotational spectra of molecules
CO-3 Apply classical and quantum mechanical models to spectroscopy
CO-4 Calculate the normal modes of simple molecules

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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4. Detailed Syllabus:

Unit 1: Introduction: Classical mechanical description of spectroscopy, quantum mechanics and energy quantization, energy-level diagram, energy spectrum: electronic states, vibrational states, rotational states, excitation and relaxation, absorption and emission of electromagnetic waves by materials


Unit 3: Molecular Spectra: Electronic spectra of diatomic and polyatomic molecules, Born-Oppenheimer approximation, Franck-Condon principle, absorption and emission spectra, fluorescence and phosphorescence, Jablonsky diagram, effect of solvation of electronic spectra, rotational spectrum of a diatomic molecule using a rigid rotator model, energy levels and spectrum of a non-rigid diatomic molecule, effect of isotopic substitution on rotational spectra, vibrational spectrum of a diatomic molecule using the harmonic and anharmonic oscillator models, vibrational-rotational coupling in a diatomic molecule, molecular spectra of chain molecules

Unit 4: Raman and Infrared Spectroscopy: Classical and quantum theory of Raman effect, normal vibrations of CO₂ and H₂O molecules, vibrational and rotational Raman spectra, basic concept of infrared spectroscopy, interpretation of Raman and IR spectra, identification of Raman-active and/or IR-active modes based on symmetry arguments

Unit 5: Introduction to Nuclear Magnetic Resonance (NMR), and Electron Spin Resonance (ESR) spectroscopy

Reference Books:

1. Physical Chemistry - P. W. Atkins
2. Fundamentals of Molecular Spectroscopy - C. N. Banwell
3. Molecular Spectroscopy - G. M. Barrow
4. Molecules and Radiation: An Introduction to Modern Molecular Spectroscopy - J. I. Steinfeld
5. Physical Chemistry – A Molecular Approach – D. A. McQuarrie and J. D. Simon

5. Teaching-Learning Strategies in brief (4 to 5 sentences):

6. Assessment methods and weightages in brief (4 to 5 sentences):

Quizzes (25%), Assignments (35%), Final Exam (40%)
Title of the Course: Chemical Kinetics and Reaction Dynamics
Faculty Name: Tapan K. Sau
Name of the Academic Program: CND
Course Code: SC2.305
L-T-P: (2-0-0)
Credits: 2

1. Prerequisite Course / Knowledge: None

2. Course Outcomes (COs):

After completion of this course successfully, the students will be able to..

CO-1. Determine the rate law for a reaction, the overall order of reaction, the integrated rate laws, the rate constants (with units) of the reactions and temperature dependence, and the order of the reaction from concentration/time plots. Apply the rate equations to determine the concentration of chemical species and order of the chemical reactions.

CO-2. Explain a reaction mechanism, identify the reaction intermediates and catalysts, determine the molecularity of each step, write the overall reaction, and explain how enzymes act as biological catalysts and why enzymatic reactions respond differently to temperature changes.

CO-3. Interpret a potential energy diagram and a reaction coordinate diagram, potential energy profiles and use them to determine the activation energy and potential energy changes for a reaction.

CO-4. Use Collision Theory to explain how reactions occur at the molecular level, the concept of activation energy and how the collision frequency, kinetic energy, temperature, and orientation of colliding reactant molecules affect the rate of a chemical reaction.

CO-5. Apply transition state theory to explain the roles of various physical factors that govern chemical reactivity.

CO-6. Describe the physical principles that govern electron transfer reactions and explain Marcus theory.

CO-7. Solve problems on chemical kinetics and reaction dynamics of unimolecular, bimolecular, and complex reactions.

CO-8. Relate experimental observations to theoretical aspects of chemical kinetics and identify applications of chemical kinetics in everyday life and industry.

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix
4. Detailed Syllabus:

**Unit 1:** Empirical chemical kinetics: Experimental techniques; The rates of reactions; Integrated rate laws; Reactions approaching equilibrium; The temperature dependence of reaction rates; Accounting for the rate laws; Elementary reactions; Consecutive elementary reactions; Impact on biochemistry: The kinetics of the helix-coil transition in polypeptides; Unimolecular reactions. (2L)

**Unit 2:** Chain reactions; The rate laws of chain reactions; Explosions; Polymerization kinetics; Stepwise polymerization; Chain polymerization; Homogeneous catalysis; Features of homogeneous catalysis; Enzymes. (2L)

**Unit 3:** Photochemistry, Kinetics of photophysical and photochemical processes; Impact on: The chemistry of stratospheric ozone; Applications: Impact on environmental sciences, biochemistry, and other areas. (1L)

**Unit 4:** Molecular Reaction Dynamics: Reactive encounters; Collision theory; Diffusion-controlled reactions; The material balance equation. (2L)

**Unit 5:** Transition state theory; The Eyring equation; Thermodynamic aspects; The dynamics of molecular collisions; Reactive collisions; Potential energy surfaces; Some results from experiments and calculations. (2L)

**Unit 6:** The investigation of reaction dynamics with ultrafast laser techniques; Electron transfer in homogeneous systems; The rates of electron transfer processes; Theory of electron transfer processes; Experimental results; Impact on biochemistry: Electron transfer in and between proteins. (2L)

**Unit 7:** Special topics (oscillating reactions, etc.). (1L)
Reference Books:


5. Teaching-Learning Strategies in brief (4 to 5 sentences):
The course involves formal lectures, quizzes, assignments and tutorials.

6. Assessment methods and weightages in brief (4 to 5 sentences):
Students’ assessment will be on the basis of:

1. Assignments: 30%
2. Quizzes: 20%
3. End-Sem Exam (*WHOLE Syllabus*): 50%

Title of the Course: Bioinformatics
NAME OF FACULTY: Nita Parekh
Name of the Academic Program: CND
Course Code: SC3.202
L-T-P: 3-1-0
(L= Lecture hours, T= Tutorial hours, P=Practical hours)

Credits: 2

1. Prerequisite Course / Knowledge: Basic Statistics and computing skills

2. Course Outcomes (COs) (5 to 8 for a 3 or 4 credit course):
After completion of this course successfully, the students will be able to
CO-1: Use various web-based bioinformatic resources (databases and tools) judiciously

CO-2: Understand and implement methods for various biological sequence analysis, viz., pattern search and sequence comparison (pairwise and multiple sequence alignments), and phylogenetic reconstruction, gene prediction

CO-3: Familiarize with the probabilistic models in biological sequence analysis

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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Note: Each Course Outcome (CO) may be mapped with one or more Program Outcomes (POs) and PSOs. Write ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low-level’ mapping

4. Detailed Syllabus:

Unit 1: Overview – Bioinformatics, Gene and Genome structure, Gene Technology – Restriction Endonucleases, Cloning vectors, DNA sequencing – PCR, cDNA and Whole Genome sequencing, NGS and third generation sequencing technologies

Unit 2: BioDatabases: Major Bioinformatics Resources – NCBI, EBI, PubMed, Primary Nucleotide and Proteins Databases - GenBank, UniProt, PDB, Genome Browsers – Ensembl, UCSC, k-mer analysis and their significance in biological sequences

Unit 3: Sequence Alignment: Pairwise Alignment – Types of pairwise alignments – Global, Local and Overlap alignments, Dot Plots, dynamic programming (DP) algorithm, Scoring matrices for nucleotides and proteins and gap penalties, Sequence-based Database Search algorithms – BLAST, FASTA, Multiple Alignment, Algorithms for Global and Local MSA – DP, Progressive based (ClustalX), Iterative methods, motif search-based methods

Unit 4: Modeling Molecular Evolution – Phylogeny: Markov models of base substitution, Computing Phylogenetic Distances, Phylogenetic Tree Construction Methods, PHYLIP

Unit 5: Gene Prediction: Gene Prediction approaches - Open Reading Frames, Homology search, Content-based methods, Markov models

Reference Books:


5. Teaching-Learning Strategies in brief (4 to 5 sentences):

The objective of the course is to familiarize the students with available web-based bioinformatics resources (databases and tools), how to use them for analysis, extract information from them, and learn to build such tools. First by taking an example of an unknown sample, what information about the sample can be obtained starting with DNA sequence by searching through available resources is provided. Next each one is given a gene sequence and they extract information about it, perform functional annotation, disease association, etc. To get a clear understanding of the methods learned for biological sequence analysis, the students implement algorithms for performing various tasks such as finding k-mers, restriction recognition sites, pairwise alignment, and gene prediction.

6. Assessment methods and weightages in brief (4 to 5 sentences):

1. Assignments – written, a mini-project using online resources, implementation of algorithms (30%), Class Quizzes + Mid-term evaluation (30%), Final exam (40%).

Title of the Course : Systems Biology
Name of the Faculty : Vinod PK
Course Code: L-T-P :3-1-0
Credits :2
( L= Lecture hours, T=Tutorial hours, P=Practical hours)

1. Prerequisite Course / Knowledge:

---------------------------------------------------------------------------------------------

2. Course Outcomes (COs) (5 to 8 for a 3 or 4 credit course):

After completion of this course successfully, the students will be able to

CO-1: Identify regulatory motifs of biological networks

CO-2: Infer the design principles of biological systems
CO-3: Analyze biological systems by mathematical modelling

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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Note: Each Course Outcome (CO) may be mapped with one or more Program Outcomes (POs) and PSOs. Write ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping.

4. Detailed Syllabus:

Unit 1: Network organization: Motifs, modules, and hierarchical networks

Unit 2: Design principles of biological systems

Unit 3: Dynamic modelling of biochemical systems

Unit 4: Biological Switches and Clocks,

Unit 5: Robustness of Biological systems

Unit 5: Biological noise

Reference Books:

1. An Introduction to Systems Biology: Design Principles of Biological Circuits by Uri Alon, Chapman & Hall

5. Teaching-Learning Strategies in brief (4 to 5 sentences):

This course builds the foundation for inferring the principles of biological systems using mathematical modelling. Lectures include solving problems in class and participation of students and include discussion on research articles. Evaluations test their ability to solve and implement models using computers.

6. Assessment methods and weightages in brief (4 to 5 sentences):
• Quiz - 20%
• End semester exam – 30%
• Assignments – 30%
• Short project – 20%

 Intro to Human Sciences

<table>
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<tr>
<th>Name of the Academic Programs</th>
<th>B.Tech. in CSE, B.Tech in ECE</th>
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<tbody>
<tr>
<td>Title of the Course</td>
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1. Prerequisite Course / Knowledge: Nil

2. Course Outcomes (COs)

After completion of this course successfully students will be able to:

CO1: Discuss the origin and development of key disciplines in the human sciences
CO2: Identify some of the fundamental questions that shape and drive inquiry in human sciences
CO3: Demonstrate knowledge of concepts related to theorizing about reflection, society, and culture
CO4: Analyze crucial normative elements and descriptive frameworks in human sciences inquiry
CO5: Develop skills to formulate nuances involved in problems concerning humans and societies
CO6: Write clear and well thought out short essays on topics in humanities and social sciences

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix
4. Syllabus:

The course will be divided into four modules, each of which will introduce students to a particular discipline in the human sciences. The various disciplines that constitute human sciences are:

1. Philosophy
2. Psychology
3. Literature
4. History
5. Sociology
6. Anthropology

Each module will offer a systematic worldview, tools of enquiry to study and analytical frameworks to make sense of topics taken up for discussion. Detailed list of topics under a module will be provided by the faculty teaching that module when the lectures begin. The overarching theme for the topics are the fundamentals of human sciences so that students grasp what humans sciences are all about.

Reference books:
Readings for each of the modules will be given with the commencement of the lectures. There is no single textbook as such for all four modules.

5. Teaching-Learning Strategies in brief:

Each module will have one faculty giving six lectures of 90 mins each. Through discipline specific modes of understanding and everyday examples, class lectures will enable students to connect and ponder about themselves, the society and cultures that surrounds them. The teaching-learning strategy emphasises the merits of avoiding simplistic solutions to complex problems and instead ask meaningful questions that enrich debates about how we produce, distribute, consume, reflect,
represent, and govern ourselves. Lectures impress upon students the need to critically reflect on issues that are impacted by technology, the historical and social context of the world they live in, the literary and philosophical ideas that permeate human thought and psychological principles of human behaviour.

6. Assessment methods and weightages in brief:

This is mainly a writing-driven course, and the evaluation questions are carefully designed to make students think independently. Students are assessed for abilities like critically assessing issues, questioning assumptions, clarifying distinctions, and bringing out nuances. In assignments and exams, students are expected to demonstrate these abilities by presenting their views clearly and systematically. Students will be evaluated for each of the four modules and the pattern of evaluation will be decided by the respective faculty.

Evaluation pattern can include weekly assignments, quizzes and term papers. Each module will carry 25% of total marks. The End Semester exam carries 25% of marks.

Basics of Ethics

Name of the Academic Programs : B.Tech. in CSE, B.Tech in ECE
Title of the Course : Basics of Ethics
Course code : HS0.203
L-T-P : 3-1-0
Credits : 2

1. Prerequisite Course / Knowledge: Nil

2. Course Outcomes (COs)

After completion of this course successfully students will be able to:

CO1: Explain the philosophical nature of the basic concepts and principles of ethics
CO2: Analyze ethical arguments for logical validity, soundness, and informal fallacies
CO3: Demonstrate the knowledge of conceptual challenges involved in normative inquiry in the ethical domain
CO4: Develop skills to formulate fundamental nuances in ethical justification and explanations
CO5: Identify the various kinds of normative elements that constitute ethical frameworks
CO6. Discuss the major tenets of normative ethical theories and their scope of application
3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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‘3’ in the box denotes ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping

4. Detailed Syllabus:

Unit I – Introduction (3 hours): Distinction between conventional and critical ethics, philosophical tools for argument analysis, intuition, evidence, justification, and explanation.

Unit II – Skepticism (4.5 hours): Intrinsic vs Instrumental value, challenge of egoism, problem of cultural relativity and subjectivism, error theory and nihilism, distinction between being ethical and seeming ethical.

Unit III – Goodness (3.5 hours): the problem of defining ‘good’, naturalistic fallacy and the open question argument, implications of the experience machine thought experiment.

Unit IV – Responsibility (3.5 hours): challenge of attributing moral responsibility to agents, the control, competence and epistemic conditions of responsibility, moral luck.

Unit V – Normative theories (5 hours): Consequentialism, deontology, and virtue ethics

Reference books:

5. Teaching-Learning Strategies in brief:
The general teaching strategy employed is the use of moral dilemmas and conceptual puzzles to introduce course topics. Lectures make use of this strategy to impress upon students the need to critically reflect on ethical issues and the relevance of doing a careful, philosophical investigation of those issues. Student interaction at this stage is aimed at bringing out conflicting ethical intuitions. This is followed up by introducing proper vocabulary to map out the problems involved in normative moral assessment. Using case studies and toy examples, ethical principles and methods of inquiry are taught so that students develop effective reasoning skills to engage with any real-world ethical matter. Student interaction and discussion at this stage is aimed to give flesh to the intuitions identified in the previous stage. The teaching-learning strategy emphasises the merits of avoiding simplistic solutions to complex ethical problems and instead ask meaningful questions that enrich moral debates.

6. Assessment methods and weightages in brief:

This is mainly a writing-driven course, and the exercise questions are carefully designed to make students think independently in ethical contexts. Students are assessed for abilities like logically dissecting issues, questioning assumptions, clarifying distinctions, and bringing out nuances. In assignments and exams, students are expected to demonstrate these abilities by presenting their views clearly, assessing competing positions systematically, anticipating possible objections to a reasoned conclusion and composing cogent responses to those objections. The assessment components and their weightages are as follows. Assignments: 60 marks, class participation: 10 marks, Mid semester exam: 10 marks, End semester exam: 20 marks.

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**Course descriptions for Elective Courses**

Title of the Course : Selected Topics in Instrumental Analysis
Name of the Faculty : Tapan K. Sau
Name of the Academic Program : CND
Course Code : SC2.310
L-T-P : (4-0-0)
Credits : 4

1. Prerequisite Course / Knowledge:
Science I / II

2. Course Outcomes (COs):
After completion of this course successfully, the students will be able to.
CO-1. Define and determine errors, accuracy and precision, S/N ratio, and detection limits of analytical methods.

CO-2. Describe the theories, fundamental principles, and applications of modern instrumental techniques for the analysis and characterization of (bio)chemical systems.

CO-3. Compare and describe strengths and limitations of various techniques.

CO-4. Apply knowledge to choose appropriate instrumentation technique(s) for specific sample analysis.

CO-5. Describe the type of information obtained from different instrumental methods.

CO-6. Identify and describe the major components of various analytical instrumentations like spectroscopy instruments, mass spectrometers, and separation instruments.

CO-7. Interpret simple UV-Vis/IR/NMR/mass spectral and chromatography data for qualitative and quantitative analysis.

CO-8. Calculate the concentrations of unknowns using sample-appropriate techniques.

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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4. Detailed Syllabus:

A. INTRODUCTION: Chemical Measurements and Instrumental Analysis. (1L)
B. ELEMENTAL ANALYSIS: Atomic Absorption and Emission Spectroscopy. (1L)
C. SPECTROSCOPIC CHEMICAL SPECIATION: Molecular Absorption and Emission; Infrared (IR); Raman Scattering; Nuclear Magnetic Resonance (NMR); Mass Spectrometry. (9L)
D. SEPARATION TECHNIQUES: Gas Chromatography; High Performance Liquid Chromatography (HPLC); Capillary Electrophoresis. (4L)
E. ELECTROANALYTICAL ANALYSIS: Cyclic Voltammetry (CV). (3L)
F. THERMAL ANALYSIS: Thermogravimetry (TG); Differential Scanning Calorimetry (DSC). (2L)
G. SURFACE ANALYSIS: BET Surface Area Analysis; X-ray Photoelectron Spectroscopy (XPS) or Electron Spectroscopy for Chemical Analysis (ESCA); Atomic Force Microscopy (AFM); Scanning Electron Microscopy (SEM). (5L)

Reference Books:


5. Teaching-Learning Strategies in brief (4 to 5 sentences):

The course will involve lectures, exercises/assignments, quizzes, tutorials, and exams.

6. Assessment methods and weightages in brief (4 to 5 sentences):
Student assessment in the course involves written tests/quizzes/assignments to determine the student learning proficiency in the course and their grades. Grading is done as follows:

<table>
<thead>
<tr>
<th>Type of Evaluation</th>
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Course of the Title: Molecular Symmetry and Quantum Mechanics (elective)

Name of the Faculty: Harjinder Singh

Name of the Academic Program: B Tech (CSE/ECE), B Tech (CSD, CXD, ECD)

Course Code: SC2.315.

L-T-P: 2(90mins)-1-0

Credits: 4

1. Prerequisite Course / Knowledge: Linear Algebra, Basic (High school) physics/chemistry

2. Course Outcomes (COs) (5 to 8 for a 3 or 4 credit course):

   - After completion of this course successfully, the students will be able to..
   - CO-1 State and prove theorems of group theory relevant to physics
   - CO-2 Apply group theory in molecular physics
   - CO-3 Derive molecular wavefunctions using symmetry behaviour of molecules
   - CO-4 Explain molecular properties using symmetry behaviour of molecules
   - CO-5 Demonstrate aspects of scientific methodology as used in abstract thinking
3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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Note: Each Course Outcome (CO) may be mapped with one or more Program Outcomes (POs) and PSOs. Write ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping

4. Detailed Syllabus:

Unit 1: Symmetry of objects, point groups, calculus of symmetry, reduced and irreducible representations, Great and Little orthogonality theorems (6L)

Unit 2: Group Theory and Quantum Mechanics, LCAO-SALC approach in MO theory, applications. (6.5L)

Unit 3: Special topics: Applications to Ligand field theory, Pericyclic reactions, Normal mode analysis of vibrational motion, etc. (9L)

Unit 4: Continuous (Lie) groups and applications (1.5L)

Reference Books:
2. M Tinkham (2003), Group Theory and Quantum Mechanics, Dover, USA
3. P W Atkins and R S Friedman (2012), Molecular Quantum Mechanics, Oxford University Press, London

5. Teaching-Learning Strategies in brief (4 to 5 sentences):
Teaching in this semester is on line. Along with prepared slides, tools are used to write material extempore and draw pictures to explain the material.

The class begins with a 5-minute quiz on concepts learned in the previous class. Students can interrupt any time with queries during the class. They can use speakers or write comments in the chat box. The instructor stops every few minutes to inquire if there are queries. Class exercises – a few in every class, are used to ensure that learning is effective.

Assignments are open for discussion before submission, though submission must be original.

Instructor is available 24X7 for discussions over the net either by a meeting or over email. This interactive process has helped the students to develop clarity on the learning material.

6. Assessment methods and weightages in brief (4 to 5 sentences):

<table>
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<tr>
<th>Activity</th>
<th>Weightage</th>
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<tr>
<td>Quizzes (23 - 5-minute quiz every class)</td>
<td>30%</td>
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<tr>
<td>Final Exam</td>
<td>35%</td>
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<tr>
<td>Assignments (8)</td>
<td>35%</td>
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Course of the Title: Open Quantum systems and Quantum Thermodynamics
Faculty Name: Samyadeb Bhattacharya
Course Code: SC1.310
Credits: 4
L - T - P: 
(Ex: Lecture hours, T-Tutorial hours, P-Practical hours)

Semester, Year: Monsoon semester, 2022
(Ex: Spring, 2022)

Pre-Requisites: Basic understanding of Quantum mechanics (graduate level), Hilbert space and linear algebra.

Course Outcomes: 
1. After the course, the students will have fundamental understanding about kinematics and dynamics of noisy quantum systems.
2. Students will also have basic ideas on current research directions in quantum thermodynamics, a little of quantum communication, quantum information and quantum entanglement detection.

3. Students will have a basic training on research in related topics through projects.

4. Students will have a firm background for pursuing a MS thesis in quantum information, communication and thermodynamics.

5. The course can be understood as a pre-PhD course related to quantum information science in general.

Course Topics:

1. Review on basic linear algebra; Metric space, Dual space, Hilbert space and bra-ket algebra.
2. Review on unitary quantum mechanics; Unitary evolution, state vectors, uncertainty principle, Schrödinger equation etc.
3. Pure and mixed states, basics on measurement theory, projective measurements, positive operator valued measures etc.
4. Non-unitary evolution, tensor product space, bi-partite quantum systems, global evolutions, non-unitary dynamics, completely positive trace preserving maps, operator-sum representation.
5. Monotones under completely positive operations, basics of distance measures and entropic measures.
6. Selected topics on complete positivity, positivity, Choi-Jamiołkowski isomorphism, Stinespring dilation, entanglement detection.
7. General quantum dynamical equations, master equation, Lindblad equation and its derivation from a few different perspectives, properties of Lindblad dynamics.
8. Basic idea on Markovianity and non-Markovianity from quantum mechanical perspectives.
9. Basic ideas on quantum heat engines and a few other selected topics on thermodynamics.


**Grading Plan**

(The table is only indicative)

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<th>Type of Evaluation</th>
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<td>Project</td>
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<td>Other Evaluation</td>
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**Mapping of Course Outcomes to Program Objectives:** (1 – Lowest, 2—Medium, 3 – Highest, or a ‘-’ dash mark if not at all relevant). Program outcomes are posted at

[https://iiitaphyd-my.sharepoint.com/:w:/r/personal/dyacad_iit_ac_in/Documents/NBA-2020-21/Course%20Content/IIIT-CSE-ECE.docx?d=w111f0effcaea41b3a4d1e8a3fbc6332d&csf=1&web=1&e=z1Khby](https://iiitaphyd-my.sharepoint.com/:w:/r/personal/dyacad_iit_ac_in/Documents/NBA-2020-21/Course%20Content/IIIT-CSE-ECE.docx?d=w111f0effcaea41b3a4d1e8a3fbc6332d&csf=1&web=1&e=z1Khby)
Teaching-Learning Strategies in brief (4-5 sentences):

The course is also self evolving. Since this course is a pre-PhD level course, it is heavily dependent on the evolution of current research in said topics. Therefore I have to modify and upgrade the course structure in regular intervals of a few years.

Note: This course description format comes into effect from Spring 2022.

Title of the course: Topics in NanoSciences
Name of the Faculty: Tapan K. Sau
Name of the Academic Program: CND
Course Code: SC2.401
L-T-P: (4-0-0)
Credits: 4

1. Prerequisite Course / Knowledge:
Science I/II

2. Course Outcomes (COs):

After completion of this course successfully, the students will be able to..

CO-1. Define terminology used in the fields of nanoscience and nanotechnology.

CO-2. Explain the nanoscale confinement effects on various material properties.

CO-3. Discuss various methods of synthesis of nanoparticles.

CO-4. Identify the factors that need control for the preparation of stable and controlled sized and shaped nanoparticles.

CO-5. Explain the determination of the particle size and shape.

CO-6. Identify and formulate appropriate methods and experimental techniques that can be used to study various nanoscale materials and phenomena.

CO-7. Analyze the size- and shape-dependent physical/chemical properties of nanoparticles.

CO-8. Identify various applications of nanoparticles and their future potential.

CO-9. Describe the advantages and limitations of nanostructured materials.

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix
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**Note:** ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low-level’ mapping

4. **Detailed Syllabus:**

**Unit 1. Introduction to Nanoscience. (3L)**

*Nanomaterials*: Definitions and Scopes.

*Length Scales*: Size Scales, Surface and Interface, Surface Energy, Coordination Numbers.

*Classification of nanomaterials*: Clusters and Magic Numbers, Nanoparticles, and Colloids. Metal, Semiconductor, and Bio Nanomaterials.

**Unit 2. Properties of Nanomaterials. (9L)**


**Unit 3. Making Nanostructures. (3L)**

Top-down and bottom-up methods.

AFM, SEM, TEM, XRD, SAXS, Nanoindentation.

**Unit 5. Applications of Nanomaterials. (4L)**

Catalysis, Band Gap Engineered Quantum Devices, Sensors, Field Effect Transistor (FET), Photovoltaic Cells, Photonic Crystals and Waveguides, Theragnostics (Magnetothermal Therapy), food and agriculture industries, automobile, textile, water treatment and civil applications, use in energy, space, and defense.

**Unit 6. Concerns and Challenges of Nanotechnology. (2L)**

Environmental, ecological and health hazards of nanoparticles. Nanotoxicology and its effect.

**Reference Books:**


5. **Teaching-Learning Strategies in brief (4 to 5 sentences):**

The course involves lectures, quizzes, laboratory demonstrations, assignments, and finding and reading relevant scientific literature.

6. **Assessment methods and weightages in brief (4 to 5 sentences):**

The student assessment in the course involves written tests/quizzes/assignments to determine their learning proficiency in the course and their grades. Grading is done as follows:

1. Assignments 20%
2. Quizzes (2*10) 20%
3. Mid-Term Exam 20%
4. End-Semester Exam (whole syllabus) 40%
Title of the Course : Nonlinear dynamics
Faculty Name : Vinod PK
Course Code : …
L-T-P : 3-1-0
Credits : 4
( L= Lecture hours, T=Tutorial hours, P=Practical hours)

1. Prerequisite Course / Knowledge:

…………

2. Course Outcomes (COs) (5 to 8 for a 3 or 4 credit course):

After completion of this course successfully, the students will be able to

CO-1: Apply geometrical, analytical, and numerical methods for analyzing non-linear dynamics

CO-2: Calculate fixed points and determine their stability

CO-3: Analyze various types of bifurcations in one and two dimensions

CO-4: Analyze limit cycles and their stability

CO-5: Analyze chaotic dynamics

CO-6: Analyze discrete maps and period doubling

CO-7: Apply theoretical methods for analyzing nonlinear dynamics to problems in sciences and engineering.

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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Note: Each Course Outcome (CO) may be mapped with one or more Program Outcomes (POs) and PSOs. Write ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping

4. Detailed Syllabus:

Unit 1: Overview: Capsule history of Dynamics, A dynamical view of world
Unit 2: One-Dimensional flows: Flows on the line, Bifurcations, Flows on the circle
Unit 3: Two-Dimensional Flows: Linear System, Phase Plane, Limit Cycles, Bifurcations
Unit 4: Chaos: Lorenz Equations, One-Dimensional Maps, Fractals

Reference Books:

1. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry and Engineering by Steven Strogatz
2. Understanding Nonlinear Dynamics by Daniel Kaplan and Leon Glass

5. Teaching-Learning Strategies in brief (4 to 5 sentences):

The course lectures will involve problem solving and simulations to analyse whether system in question settles down to equilibrium, keeps repeating in cycles or does something more complicated. The emphasis will be on geometric thinking, computational and analytical methods. Interactive tools are used to enhance the understanding. Project ideas from various disciplines (both engineering and sciences) are considered for the assessment.

6. Assessment methods and weightages in brief (4 to 5 sentences):

- Quiz - 20%
- End semester exam – 30%
- Assignments – 30%
- Project – 20%

Title of the course : Advance Bioinformatics
Name of the Faculty : Nita Parekh
Name of the Academic Program : CND  
Course Code : L-T-P : 3-1-0  
(L= Lecture hours, T= Tutorial hours, P= Practical hours)  
Credits : 4

1. Prerequisite Course / Knowledge: Bioinformatics Course, Basic Statistics and computing skills

2. Course Outcomes (COs) (5 to 8 for a 3 or 4 credit course):

After completion of this course successfully, the students will be able to

CO-1: Learn, extract and utilize information related to structure-function analysis of proteins

CO-2: Develop methods for various biological data analysis, viz., secondary structure prediction, Hidden Markov model for pattern search, e.g., CpG islands, gene prediction, etc. and sequence comparison (pairwise and multiple sequence alignments), and phylogenetic reconstruction, gene prediction

CO-3: Learn to perform genome analysis to understand evolutionary relatedness between species at various levels, viz., genes, proteins, noncoding conserved regions, horizontally transferred regions, etc.

CO-4: Perform high-throughput data analysis, such as microarray data analysis, computational proteomics, protein interaction networks.

CO-5: Familiarize with various sequence and structural variations in human genome and their functional impact

CO-6: The course provides breadth and depth of various types of bioinformatics data analysis and prepares a student to embark on a research project.

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

|   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO1 | PO1 | PO1 | PO2 | PSO | PSO | PSO | PSO |
|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| CO1| 3   |     |     |     |     |     |     |     |     |     |     |     |     | 2   |     |     |     |
| CO2|     |     |     | 3   |     | 3   |     |     |     | 3   |     |     | 3   |     |     |     |     |
| CO3|     |     | 3   | 3   |     |     |     |     |     |     |     |     |     |     |     | 3   |     |     |

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Note: Each Course Outcome (CO) may be mapped with one or more Program Outcomes (POs) and PSOs. Write ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping

4. Detailed Syllabus:

Unit 1: Statistical approaches for pattern search. Markov Chains and Hidden Markov models and their applications in identifying CpG islands and gene prediction. Viterbi algorithm, Forward and Backward algorithms, Baum-Welsch algorithm

Unit 2: Genome Variation Analysis. Types of Genomic Variations – Tandem & Interspersed Repeats, Segmental Duplications, SNPs & Haplotypes, Copy Number Variations (CNVs). Polybayes approach to SNP identification, SNP-Haplotype

Unit 3: Clustering techniques – Distance measures, Linkage rules, Hierarchical clustering. Application to Bioinformatics - In Phylogeny Construction, Clustering of EST Sequences, Clustering of Gene Expression Data, Clustering Mass Spectral Data

Unit 4: Structural classification of Proteins. Statistical, Physico-chemical and machine learning methods, e.g., Chou-Fasman method, GOR method, Nearest Neighbour methods, Neural networks, Patterns of hydrophobic amino acids, Hydrophobic moment, SSP accuracy – Mathews correlation coefficient, Jackknife test, NR-dataset

Unit 5: Protein Structure Prediction. Homology determination based on full-length sequence information – PSI-BLAST, PIRSF, COGs & KOGs, MSA, SSP, Identifying domains, Homology Modeling - Finding a structural template for protein sequence, Homology determination based on 3D-structural information – comparative homology, fold recognition methods, Alignment of sequence to tertiary structure, ab initio methods, Based on sequence and structural motifs, Genetic Algorithm


Reference Books:


5. Teaching-Learning Strategies in brief (4 to 5 sentences):

The objective of the course is to familiarize the students with mathematical, algorithmic, and computational foundations of common tools used in genomics and proteomics. Hands-on sessions on using various bioinformatics resources and implementation of algorithms would give them necessary skills to build similar tools for their research. At the end of the course the students would have a good idea about the computational approaches in biological data analysis and also learn to how to use them intelligently. This would prepare them for their research work.

6. Assessment methods and weightages in brief (4 to 5 sentences):

1. Assignments – written, implementation of algorithms and tutorial session (25%), Class Quizzes + Two Mid-term evaluation (35%), Final exam (40%)

Title of the Course : Introduction to Particle Physics
Faculty Name : Subhadip Mitra
Course Code : SC1.42
L-T-P : 3-1-0.
Credits : 4
(L= Lecture hours, T=Tutorial hours, P=Practical hours)

1. Prerequisite Course / Knowledge:

Some exposure to Quantum Mechanics & basic Mathematics (i.e., some linear algebra & complex analysis, basic group theory etc.) and most importantly, interest about the subject.
2. **Course Outcomes (COs):**

After completing this course successfully, the students will be able to

**CO-1** Describe the particle content of the Standard Model.

**CO-2** Discover the various types of interactions among the elementary particles/antiparticles and the role of various symmetries and classify the particles according to their quantum numbers.

**CO-3** Discover the representation of elementary processes with Feynman diagrams.

**CO-4** Recognize the relativistic generalization of Quantum Mechanics through the Klein-Gordon and Dirac equations and outline the basic workings of Quantum Electrodynamics.

**CO-5** Apply their knowledge and calculate simple processes (like two-body decay or two-going-to-two scattering, etc.).

3. **Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix**

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Note: Each Course Outcome (CO) may be mapped with one or more Program Outcomes (POs) and PSOs. Write ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping

4. **Detailed Syllabus:**

Unit 1: Introduction: developments throughout the 19th century as the backdrop. From abstract atoms to the Large Hadron Collider, Elementary particles and forces, the Standard Model.

Unit 2: Relativistic kinematics and Symmetries of nature: the SU(2) & SU(3) groups and their connections with the elementary particles, discrete symmetries, antiparticles.
Unit 3: The Klein Gordon equation & the basics of the perturbation theory.

Unit 4: Core Concepts: Electrodynamics of spin-less particles, Feynman diagrams and rules, Dirac equation, Quantum Electrodynamics

Unit 5: Advanced Topics: Parton model and a little QCD, collider physics – a (very) quick tour, introduction to HEP computing – Monte Carlo tools, some basic simulations, challenges in modern particle physics, role of modern computing

Reference Books:

2. F Halzen and A D Martin, Quarks and Leptons, John Wiley & Sons.

Teaching-Learning Strategies in brief:

This is an introductory (elective) course on Particle Physics designed to give the students who have no prior exposure to Quantum Field Theory a broad overview and some taste of the exciting world of Particle Physics. The approach would be somewhat intuitive. The design is for students with diverse backgrounds. The focus would be on concepts, simple explanations, and intuition building.

Assessment methods and weights in brief:

Assignments + Quizzes – (30%), Mid-term evaluation (30%), Final exam (40%)

Course Title: Machine Learning for Natural Sciences
Faculty Name: Prabhakar Bhimalapuram
Course Code: SC1.421
L-T-P: 4-0-0
Credits: 4
(L= Lecture hours, T=Tutorial hours, P=Practical hours)

Prerequisite Course / Knowledge:

Probability & Statistics, Linear Algebra, Statistical Models in AI

Course Outcomes (COs):

After completion of this course successfully, the students will be able to...

CO-1: Learn and demonstrate understanding the basic concepts in machine learning
CO-2: Demonstrate use of machine learning algorithms on simple problems

CO-3: For a selected problem, apply the understanding of the principles, to formulate a problem statement

CO-4: Build Models based on requirements of the problem statement

CO-5: Analyze the constructed models for their usefulness, find deficiencies and identify possible improvements.

Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

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‘3’ for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping.

Detailed Syllabus:

Unit 1: Overview: Types of problems: regression, classification. Types of machine learning: (a) supervised, (b) unsupervised, (c) semi-supervised and (d) reinforcement learning

Unit 2: Problem specific issues:
(a) representation: how to decide on a model that can solve the problem at hand?
(b) evaluation: Construction of a loss function to evaluate the
(c) Optimization: methods to use to iteratively improve the model from a starting guess?

Unit 3: Review of prominent current literature in ML as applied to natural sciences

Unit 4: Project discussion and implementation: Selection of a problem in natural sciences and developing a solution using ML techniques

Reference Books:
1. “Probabilistic Machine Learning”, Kevin Murphy, MIT Press 2022
2. Other material (websites, technical articles) will be given to the students, based on need.

Teaching-Learning Strategies in brief (4 to 5 sentences):

Lectures will initially introduce the motivations, concepts, definitions along with simpler examples. This will be followed by assignments and quizzes that will make sure that the students have understood the concepts. These will be followed by deeper lectures and assignments which lead the students to the bigger questions in the area. These will also be supplemented with real world engineering problems so that they can apply the concepts learned by them.

Assessment methods and weightages in brief (4 to 5 sentences):

- Light In-class Quizes: 15%
- Assignments: 15%
- Mini Project: 20%
- Major Project: 50%

Title of the Course : Physics of Soft Condensed Matter
Name of the Faculty : Marimutu Krishnan
Course Code : L-T-P:
Credits : 4

1. Prerequisite Course / Knowledge:

Science-I and Science-II (for non-CND students); thermodynamics and basic statistical mechanics (for CND students)

2. Course Outcomes (COs) (5 to 8 for a 3 or 4 credit course):

After completion of this course successfully, the students will be able to

CO-1 Apply theoretical and numerical methods to analyze the structure and dynamics of soft condensed matter
CO-2 Analyze the time evolution of phase space probability density functions for many-body systems
CO-3 Calculate radial distribution functions and structure factors for condensed systems
CO-4 Explain density fluctuations and fluctuation dissipation theorem
CO-5 Calculate radial distribution functions and structure factors for condensed systems
CO-6 Explain fluctuation theorems for non-equilibrium systems
3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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Lectures will introduce the basic concepts and recent advances in soft condensed matter physics, with particular emphasis on the equilibrium and non-equilibrium properties of simple liquids, biopolymers, and macromolecular assemblies. This will be followed by lectures on theoretical tools needed to understand many-body systems and some discussion on experimental techniques commonly used to probe soft condensed matter. The course will also have hands-on sessions on computational analyses of condensed matter systems. As part of reading assignments, students will be asked to read and present some research articles on some interesting soft condensed matter systems. Class assignments and mid-term exams will be used evaluate students' understanding of concepts covered in the course. Computational projects will be given at the end of the course, which will enable students to apply the concepts to some real-world problems.

6. Assessment methods and weightages in brief (4 to 5 sentences):
Mid-term exams (20%), Assignments (20%), Final Exam (30%), Projects (30%)

Title of the course : Introduction to Quantum Field Theory
Name of the Faculty : Diganta Das
Name of the Academic Program : CND
Course Code : SC1.421
L-T-P : 3-1-0.
Credits : 4
( L= Lecture hours, T=Tutorial hours, P=Practical hours)

1. Prerequisite Course / Knowledge:
Quantum Mechanics, Special Theory of Relativity.

2. Course Outcomes (COs):
After completing this course successfully, the students will be able to

CO-1 Explain the need for a quantum field theoretic description of nature
CO-2 Recognize the basic differences between wave function and quantum field.
CO-3 Discuss the idea of second quantization
CO-4 Apply second quantization to scalar, spinor, and electromagnetic field
CO-5 Calculate transition amplitudes and scattering cross-section for different processes
CO-6 Recognize the conceptual challenges in the quantum field theory
3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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Note: ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping

4. Detailed Syllabus:

Unit 1: Introduction: review of backgrounds, motivations for QFT

Unit 2: Elements of Classical Field Theory: symmetries and Noether's theorem

Unit 3: Functional Formalism: path integral formalism, functional quantization, Feynman diagrams, quantization of scalar field, phi-4 theory

Unit 4: S-matrix: scattering cross-section and decay rates, from Feynman diagrams to S-matrix

Unit 5: Dirac Field: Dirac equation and its solutions, gamma matrices, quantization, Green's function

Unit 6 Quantum Electrodynamics (QED): Feynman rules for QED, cross-section of simple QED processes

Unit 7 Introduction to Renormalization

Reference Books:

1. A. Zee: Quantum Field Theory in a Nutshell
2. Ashoke Das: Field Theory—A Path integral Approach
4. Lewis H. Ryder: Quantum Field Theory
5. Amitabha Lahiri & Palash B. Pall: A First Book of Quantum Field Theory
6. David Tong: Quantum Field Theory

7. Michael E. Peskin & Daniel V. Shroeder: An Introduction to Quantum Field Theory

5. Teaching-Learning Strategies in brief (4 to 5 sentences):

Aim of the course is to introduce to the students the main concepts and mathematical framework of Quantum Field Theory. A typical class consists of discussion of a new concept and its underlying mathematical structure. To make teaching more interactive in the online mode, instead of showing slides, mathematical derivations are done live during the class. Refined versions of the class materials is then circulated to the students. Students are encouraged to go through the materials and work out the mathematical derivations for better understanding of the concepts. Assignments are given on a regular basis. The assignments are designed in such a way that students can apply the concepts to solve problems. At the end of the course students will acquire several tools of Quantum Field Theory.

6. Assessment methods and weightages in brief (4 to 5 sentences):

Assignments: 30%, Quizzes (Mid-sem exams): 30%, End Semester: 40%

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Title of the Course: Next Generation Sequence Data Analysis
NAME OF FACULTY: Nita Parekh
Course Code: SCI653
L-T-P: 3-1-0
(L= Lecture hours, T=Tutorial hours, P=Practical hours)
Credits: 4

Name of the Academic Program: CND

1. Prerequisite Course / Knowledge: Bioinformatics Course

2. Course Outcomes (COs) (5 to 8 for a 3 or 4 credit course):

After completion of this course successfully, the students will be able to

CO-1: Handle confidently different types of next generation sequencing data.

CO-2: Appreciate mathematical and algorithmic concepts for whole genome and exome assembly, both reference-based and de novo and learn to carry out the analysis on real data.
CO-3: Identify different types of variations in NGS data, viz., small sequence variations, copy number variations, insertions and deletions, inversions and translocations, and annotate the variants.

CO-4: Perform differential gene expression analysis using NGS data

CO-5: Use judiciously different tools and databases for end-to-end analysis of NGS data.

The course provides in-depth hands-on analysis of NGS data using various publicly available resources and prepares the student for his research.

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

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4. Detailed Syllabus:

Unit 1: Workflow of NGS data analysis, Types of reads - single-end, paired-end, mate-pairs

Sequencing technologies – Illumina, SOLiD, 454 - read lengths, accuracy, biases introduced, etc.

Applications of NGS sequencing - RNA-Seq, De novo sequencing, non-coding RNA sequencing, bisulphite sequencing, metagenomics by NGS, etc.

Unit 2: Introduction to some basic Unix/Linux/R commands, NGS Data Formats - FASTA, FASTQ, SFF, VCF, SAM/BAM, etc., Parsing NGS Files (Accessing, Querying, Comparing, etc.)
Unit 3: Algorithms in Short Read Alignments. Alignment based assembly – Bowtie, BWA, De novo assembly – de Brujin graph. Tools for alignment based assembly - Bowtie (genome), BWA (genome), HISSAT (transcriptome)

Unit 4: Downstream analysis of alignment based assembly. Methods for identification of variants (genome-level), Data-preprocessing, Data pretreatment, Data analysis for Single nucleotide variations (SNVs), Structural variations (SVs) - CNVs, indels, inversions and translocations, Visualization and Annotation of variants, Differential gene expression analysis (CuffDiff) – (transcriptome-level)

Unit 5: Tools for de novo assembly - Velvet (genome), Soapdenovo (genome), Cufflinks (transcriptome). Downstream analysis of de novo assembly - Genome annotation, Enrichment analysis

Unit 6: Small RNA analysis

Reference Books:
1. Research Papers (to be uploaded on course website)
2. Algorithms for Next Generation Sequencing, Wing-Kin Sun

5. Teaching-Learning Strategies in brief (4 to 5 sentences):

The course will provide the skills to perform comprehensive genome analysis using next generation sequencing data, both at the whole-genome level (WGS) and transcriptome-level (RNAseq). A major component of the course is hands-on-sessions, wherein various publicly available resources will be used to carry out the analysis on real genome/transcriptome data to address biological problems. The course structure will be one theory lecture followed by one lab session. The course also has a project component wherein the students will carry an end-to-end genome analysis using NGS data for a biological problem and submit a term paper on some recent application of NGS data analysis.

6. Assessment methods and weightages in brief (4 to 5 sentences):

Assignment - 15%
Term paper + Project - 15%,
Mid semester exams - 20%
End semester exam - 50%

Title of the Course : Molecular Modeling and Simulations
Name of the Faculty : U Deva Priyakumar
Course Code : 
L-T-P : 3-1-0
Credits : 4
Name of the Academic Program: BTech &BTech+MS dual degree programs

( L= Lecture hours, T=Tutorial hours, P=Practical hours)

1. Prerequisite Course / Knowledge:

None

2. Course Outcomes (COs):

After completion of this course successfully, the students will be able to

CO-1: Describe the different aspects of molecular modeling techniques

CO-2: Describe the fundamental methods of quantum chemistry, molecular mechanics, molecular dynamics in the context of modelling molecular systems

CO-3: Examine properties of molecules using quantum chemical methods

CO-4: Evaluate the dynamic characteristics of biomolecules such as protein, DNA and RNA using molecular dynamics simulations.

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

|    | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PO14 | PO15 | PO16 | PO17 | PO18 |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|
| CO1| 3   | 2   | 1   | 2   | 1   | 1   | 1   | 1   | 1   | 1    | 1    | 3    | 1    | 2    | 1    | 2    |      |
| CO2| 2   | 2   | 1   | 2   | 1   | 1   | 1   | 1   | 1   | 1    | 1    | 2    | 1    | 2    | 1    | 2    |
| CO3| 2   | 3   | 2   | 1   | 2   | 2   | 1   | 1   | 1   | 1    | 2    | 1    | 2    | 2    | 2    | 2    |
| CO4| 2   | 3   | 2   | 2   | 3   | 2   | 1   | 1   | 1   | 2    | 1    | 1    | 2    | 2    | 2    | 3    |
| CO5|     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| CO6|     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
| CO7|     |     |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |
Note: Each Course Outcome (CO) may be mapped with one or more Program Outcomes (POs) and PSOs. Write ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping

4.Detailed Syllabus:

Unit 1: Potential energy surface: Concepts of minima, transition states and higher order saddle points. Optimization methods: gradient descent, conjugate gradient and Newton-Raphson methods

Unit 2: Basics of Quantum mechanics: Particle in a box, Hydrogen atom problem, two-body problem, molecular orbital theory

Unit 3: Practicals of quantum chemistry: Optimization of molecules, Understanding of the different components of the outputs, calculation of properties like the IR spectrum

Unit 4: Molecular mechanics: Force field equations, Additive forcefields, polarizable and machine learning forcefields

Unit 5: Molecular dynamics simulations: Integrating Newton’s laws of motion with force derived from force fields, replica exchange simulations, umbrella sampling simulations

Unit 6: Practicals of molecular dynamics: Set up necessary requirements for MD simulations, perform short simulations, calculation of thermodynamic properties.

Reference Books:
1. Molecular Modeling by Andrew Leach
2. Molecular Modeling and Simulations by Tamar Schlick

5.Teaching-Learning Strategies in brief (4 to 5 sentences):

The course aims to enable students to model a given chemical or biological molecular process. Lectures followed by practicals on the same aspects will be done in tandem. A bird’s eye view will be followed where the emphasis is more on the philosophical understanding of the methods than elaborate derivations of all concepts. The evaluations will be continuous and will test the students’ understanding of concepts and their implementations in performing a given task.

6.Assessment methods and weightages in brief (4 to 5 sentences):

- Assignments - 20%
· Quiz - 30%
· Exams - 50%

<table>
<thead>
<tr>
<th>Title of the Course</th>
<th>Physics of Early Universe</th>
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<tbody>
<tr>
<td>Name of the Faculty</td>
<td>Diganta Das</td>
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<td>Name of the Academic Program</td>
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<td>Credits</td>
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( L= Lecture hours, T=Tutorial hours, P=Practical hours)

1. Prerequisite Course / Knowledge:
Differentiation and integration, classical mechanics, electricity and magnetism

2. Course Outcomes (COs) (5 to 8 for a 3 or 4 credit course):
After completing this course successfully, the students will be able to

CO-1 Explain the large-scale structure of the universe and its observational components

CO-2 Demonstrate understanding of how mass, radiation distribution shapes the dynamics of the universe

CO-3 Apply their knowledge and calculate dynamical properties of few model universe

CO-4 Discover the thermal history of the early universe

CO-5 Familiarize themselves with several unsolved problems in the research of cosmology

3. Mapping of Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs) – Course Articulation Matrix

<table>
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<tr>
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Note: Each Course Outcome (CO) may be mapped with one or more Program Outcomes (POs) and PSOs. Write ‘3’ in the box for ‘High-level’ mapping, 2 for ‘Medium-level’ mapping, 1 for ‘Low’-level’ mapping.

4. Detailed Syllabus:

Unit-1: Universe Observed: Expansion. Isotropy and homogeneity. Age. Cosmic microwave background


Unit-3: Black-body radiation and the early history: Observation of CMB. Recombination and decoupling.

Last scattering. Temperature fluctuations


Unit-5: Inflation: Flatness, horizon, and monopole problem. Physics of inflation

Reference Books:

1. Barbara Ryden: Introduction to Cosmology
2. Matts Roos: Introduction to Cosmology

5. Teaching-Learning Strategies in brief (4 to 5 sentences):

This is an introductory course to cosmology. The course is for students who do not have any knowledge of cosmology. It is also designed to be taught to students from diverse background of science. In each lecture session, the focus will be on building concepts and intuition about the physics. It will be followed by hands-on session where application of the concepts to simple problems will be practiced.

6. Assessment methods and weightages in brief (4 to 5 sentences):
Assignments: 30%,
Quizzes: 30%,
End Semester: 35%,
Attendance: 5%

List of Electives
Advanced Algorithms
Advanced Biology
Advanced Biomolecular Architecture
Advanced Computer Networks
Advanced Data Systems
Advanced NLP
Advanced Optimization: Theory and Applications
Advances in Robotics & Control
Algorithms and Operating Systems
Analog IC Design
Applied Electromagnetics
Behavioral Research & Experimental Design
Behavioral Research: Statistical Methods
Biomolecular Structure Interaction & Dynamics
CMOS Radio Frequency Integrated Circuit Design
Cognitive Neuroscience
Cognitive Science and AI
Compilers
Computational Social Science
Computer Vision
Data Analytics I
Data Foundation Systems
Data Systems
Design for Social Innovation
Design for Testability
Differential Equations
Digital Image Processing
Digital VLSI Design
Distributed Data Systems
Distributed Systems
Distributing Trust and Block Chains
Eco-Informatics
Environmental Science & Technology
Fairness, Privacy and Ethics in AI
Flexible Electronics
FPGA based Accelerator Design
Functional Analysis
Green Buildings
Hydro Informatics
ICTs for Development
Information Retrieval & Extraction
Information Security Audit and Assurance
Internals of Application Servers
Intro to Cognitive Science
Intro to UAV Design
Introduction to Game Theory
Introduction to Neural and Cognitive Modeling
Introduction to Neuroeconomics
Introduction to NLP
Introduction to Stochastic Processes
Linear Partial Differential Equations and Variational Calculus
Mathematical Models in Biology
Mechatronics System Design
Mobile Robotics
Modern Complexity Theory
Multivariate Analysis
Music, Mind, and Technology
Online Privacy
Optical Remote Sensing
Optimization Methods
Principles of Information Security
Principles of Programming Languages
Principles of Semiconductor Devices
Quantum Algorithms
Radar Systems
Real-Time Systems
Research in Information Security
Robotics: Dynamics and Control
Robotics: Planning and Navigation
Signal Detection and Estimation Theory
Social Science Perspective on HCI
Software Engineering
Spatial Data Sciences
Spatial Informatics
Speech Signal Processing
Statistical Methods in AI
System and Network Security
Technology Product Entrepreneurship
Time Frequency Analysis
Topics in Applied Optimization
Topics in Deep Learning
Topics in Machine Learning
Topics in Signal Processing
Topics in Software Engineering
Topics in Software Foundations
Wireless Communications