ELECTIVE COURSES IN MATHS FOR JAN-MAY 2022

Note: This list is subject to changes.

(1) **Introduction to Modular Forms**
   (a) Instructor: Siddhi Pathak
   (b) Syllabus:
      (i) the modular group;
      (ii) elliptic functions;
      (iii) modular functions;
      (iv) modular forms of level 1 - the space of modular forms, Fourier expansions, Ramanujan τ-function, Hecke operators, Petersson inner product;
      (v) congruence subgroups and modular forms of higher level;
      (vi) if time permits - θ functions and modular forms of half-integer weight.
   (c) Textbooks:
      (i) A course in arithmetic by J.-P. Serre.
      (ii) Problems in the theory of modular forms - M. R. Murty, M. Dewar, H. Graves.
      (iii) Introduction to elliptic curves and modular forms - Neal Koblitz.
   (d) Prerequisites: Complex analysis, Algebra 1 and Algebra 2.
   (e) Target audience: BSc 3rd year, MSc Maths

(2) **Model Theory**
   (a) Instructors: Manoj Kummini & S P Suresh
   (b) Syllabus:
      (i) Basic model theory – compactness, completeness, Lowenheim-Skolem theorems, complete theories.
      (ii) Quantifier elimination – algebraically closed fields, real closed fields, applications.
      (iii) Realising and Omitting Types – Prime models, saturated models
      (iv) Ramsey's Theorem and indiscernibles
   (c) Textbooks:
      (i) Marker, Model Theory.
      (ii) Poizat, A Course in Model Theory.
   (d) Prerequisites:
      (i) Knowledge of basic first-order logic. Logic course at CMI is recommended.
      (ii) basics of algebra: definitions and basic properties of groups, rings and fields.
   (e) Target audience: BSc 3rd year, MSc CS/Maths

(3) **Commutative Algebra II**
   (a) Instructor: Sudeshna Roy
   (b) Syllabus: Regular sequences and depth, Koszul complexes, Cohen-Macaulay rings, Injective modules, Matlis duality, Canonical modules, Gorenstein rings, Local cohomology.
   (c) Textbooks: Cohen-Macaulay Rings by W. Bruns and H. Herzog.
   (d) Prerequisites: Commutative algebra 1.
   (e) Target audience: BSc 3rd year, MSc Maths

(4) **Combinatorics and Commutative Algebra**
   (a) Instructor: S. Selvaraja
   (b) Syllabus: This course is planned to introduce some of the combinatorial aspects of commutative algebra. There will be three streams of lectures - Grobner bases, Stanley-Reisner ring of a simplicial complex, and Edge ideals of graphs. The detailed course plan with weekly Syllabus will be made available later.
   (c) Textbooks (reference books):
      (i) David Cox, John Little, and Donal O'Shea, Ideals, varieties, and algorithms.
      (ii) W. Bruns and J. Herzog. Cohen-Macaulay rings.

(iii) J. Herzog and T. Hibi. Monomial ideals.
(iv) E. Miller and B. Sturmfels, Combinatorial Commutative Algebra.
(v) R. H. Villarreal, Monomial algebras.
(d) Prerequisites: Commutative algebra 1 and a course on homological algebra.
(e) Target audience: BSc 3rd year, MSc Maths

(5) **Algebraic Groups**
(a) Instructor: Arpita Nayek
(b) Syllabus: Affine algebraic groups: basic concepts and examples, actions of algebraic groups on varieties, Lie algebra of an algebraic group, the adjoint representation, homogeneous spaces, Jordan-Chevalley decomposition, diagonalizable groups.
(c) Textbooks: Linear algebraic groups by J. E. Humphreys.
(d) Prerequisites: Knowledge of commutative algebra and basic algebraic geometry.
(e) Target audience: MSc Maths

(6) **Introduction to Valuation Theory**
(a) Instructor: Suprajo Das
(b) Syllabus: applications of valuation theory to resolution of surface singularities in characteristic 0 will be discussed.
(c) Textbooks:
(i) Ramification theoretic methods in algebraic geometry by S. Abhyankar.
(ii) Resolution of singularities by D. Cutkosky.
(iii) "Valuation Theory" chapter from Commutative Algebra vol. II by O. Zariski & P. Samuel.
(d) Prerequisites: Basic commutative algebra and chapter 1 of Hartshorne's "Algebraic Geometry"
(e) Target audience: BSc 3rd year, MSc Maths

(7) **Algebraic geometry II**
(a) Instructor:V. Balaji
(b) Syllabus: TBA
(c) Textbooks: TBA
(d) Prerequisites: Algebraic geometry I
(e) Target audience: BSc 3rd year, MSc Maths

(8) **Semisimple Lie Algebras**
(a) Instructor: S. Senthamarai Kannan
(b) Syllabus: TBA
(c) Textbooks: TBA
(d) Prerequisites: TBA
(e) Target audience: BSc 3rd year, MSc Maths

(9) **Algebra IV**
(a) Instructor: V. Balaji
(b) Syllabus: Modules, generators and relations, structure theorem for Abelian groups/modules of Euclidean domains/PIDs. Applications to linear operators. Galois theory: separable and normal field extensions, fundamental theorem of Galois theory.
(c) Textbooks:
(i) M. Artin, Algebra, Prentice Hall of India.
(ii) E. Artin, Galois Theory.
(iii) S. Lang, Algebra
(d) Prerequisites: Algebra III
(e) Target audience: BSc 3rd year students.

(10) **Game Theory**
(a) Instructor: T. Parthasarathy / Sujatha Babu.
(b) Syllabus: Matrix games with examples. A constructive proof of minimal theorem using Linear Programming. Will discuss nonzerosum bimatrix games and the concept of Nash Equilibrium points. Lemke-Howson algorithm will be explained to construct an equilibrium Pair for bimatrix games. Several solution concepts will be introduced for cooperative games. Stochastic games will be mentioned and show how it differs from matrix games.

(c) Textbooks:
  (i) T Parthasarathy and Sujatha Babu, *Stochastic Games and Related Concepts*, Hindustan Book Agency,
  (ii) Other references will be given during the course.
(d) Target audience: BSc 2nd/3rd year, MSc.

(11) **Topological Data Analysis**
(a) Instructor: Priyavrat Deshpande
(b) Syllabus: simplicial complexes, persistent homology, vectorization methods, the mapper algorithm, manifold learning. (This is a 2 credit course offered in the first half.)
(c) Textbooks: There is no specific textbook. Appropriate references/ papers will be provided during the course.
(d) Prerequisites: Profeciency in Python. Maturity in the following topics - metric spaces, linear algebra, classification.
(e) Target audience: BSc 3rd year, MSc CS/ DS/ Maths.

(12) **Introduction to Graph Theory**
(a) Instructor: Sarad Sane
(b) Syllabus:
  (i) Basic concepts, various kinds of graphs, Havel-Hakimi theorem, Erdos-Gallai theorem, Breadth-first and depth-first search trees.
  (ii) Matchings, vertex and edge cover, Tutte's theorem.
  (iii) Connectivity, Menger's theorem, Ford-Fulkerson algorithm, Gale-Ryser theorem.
  (iv) Graph colourings.
  (v) Hamilton property.
  (vi) Planar graphs.
  (vii) Ramsey theory.
  (viii) Probabilistic graph theory.
(c) Textbooks:
  (i) West, Introduction to Graph Theory, Prentice Hall India.
  (ii) Bondy and Murty, Graph Theory and Applications, Springer.
  (iii) Diestel, Introduction to Graph Theory, Springer.
(d) Prerequisites: TBA
(e) Target audience: BSc 2nd/3rd year, MSc.

(13) **Stochastic Processes II**
(a) Instructor: S. Ramasubramanian
(b) Syllabus:
  (i) Brief review of continuous random variables.
  (ii) Poisson Processes: Time- homogeneous Poisson process, waiting times, Inter arrival times, order-statistics property, non-homogeneous Poisson Processes, Examples.
  (iii) Compound Poisson processes, examples.
  (iv) Continuous-time Markov chains, brief discussion.
  (v) Birth and death processes: Backward and forward Kolmogorov equations, examples.
  (vi) Brownian motion: Brief discussion and some elementary aspects of One-dimensional Brownian motion, Brownian motion with drift, transition probability density function.
(c) Textbooks:
  (i) S. M. Ross: Stochastic Processes
  (ii) V. I. Rotar: Probability and Stochastic Modelling.
  (iii) Hoel, Port and Stone: Introduction to Stochastic Processes.
(d) Prerequisites: Stochastic Processes I.
(e) Target audience: BSc 3rd year, MSc Maths/CS/DS

(14) **An introduction to von Neumann algebras**
(a) Keshab Bakshi and Sruthymurali
(b) Syllabus: Topologies on spaces of operators, bounded linear operators on Hilbert spaces, von Neumann algebras and examples, the geometry of projections, classification of von Neumann algebra, relation between von Neumann alegebras and its commutants.

(c) Textbooks: Lectures on von Neumann algebras by Serban Stratila and Laszlo Zsido
(d) Prerequisites: Functional analysis.
(e) Target audience: BSc 3rd year, MSc Maths

(15) **Partial Differential Equations**
(a) Instructor: Mythily Ramaswamy
(b) Syllabus:
(i) Overview : Wellposed PDEs, Major examples of first and second order PDEs and some solution methods.
(ii) First order PDEs : Solution by method of characteristics.
(iii) Classification of second order PDEs, Solution by separation of variables and Fourier Series for Laplace, Heat and Wave equations.
(iv) Laplace Equation : Fundamental Solution, Mean Value Properties, Maximum Principle, Poisson Equation.
(v) Heat Equation : Fundamental Solution, Maximum Principle.
(vi) Wave Equation : One dimensional wave equation and its solution, Higher dimensional wave equation.
(c) Textbooks:
(i) McOwen, PDE; Methods and Applications, Pearson.
(ii) L.C. Evans, PDE, Graduate Studies in Mathematics, Vol 19, AMS.
(iii) Qing Han, Basic course in PDE, Graduates studies in Mathematics, Vol 120, AMS
(iv) Pinchover and Rubinstein, Introduction to PDE
(d) Prerequisites: Multivariable calculus, ODE theory.
(e) Target audience: BSc 3rd year, MSc Maths