राष्ट्रीय विज्ञान शिक्षा एवं अनुसंधान संस्थान भुवनेश्वर
(परमाणु ऊर्जा विभाग, भारत सरकार का एक स्वायत्त संस्थान)
NATIONAL INSTITUTE OF SCIENCE EDUCATION AND RESEARCH BHUBANESWAR
(An autonomous Institution under Department of Atomic Energy, Govt. of India)

प्रो. बेदांगदास महांति, एफएनए, एफएएससी, एफएनएएससी
भौतिक विज्ञान विभाग
Prof. Bedangadas Mohanty, FNA, FASc, FNASc
School of Physical Sciences

8th October 2020

Dr. A. K. Dureja,
Associate Dean and Professor,
Homi Bhabha National Institute,
R. No. 209, Second Floor, B Wing,
Training School Complex,
Anushaktinagar,
Mumbai - 400 094, India
Email :dureja@hbni.ac.in

Dear Dr. Dureja,

We had received from you on 20th August 2020, via email, a course related to Integrated MSc students at NISER for Minor in Computer Science for discussion in the UG BoS, HBNI.

The BoS has discussed the course via email circulation. Based on suggestions from the members and the suggestion given by you in the email, a revised course was submitted to us. The same was again discussed in BoS and members have given their **approval** to the revised course. The revised course is attached to this letter for your consideration.

One of the main revision is that the credit structure has been made consistent with HBNI guidelines. The BoS discussed and feels that the proposed courses are suitable for Integrated MSc students at NISER for Minor in Computer Sciences.

If there are any further suggestions for the BoS, kindly let us know.

Thanking you.

with best regards,
BMohanty
(Bedangadas Mohanty,
Convenor BoS UG, HBNI)

Attachment: BoS approved course related to Integrated MSc students at NISER for Minor in Computer Science

The following courses are submitted for approval. The courses will be floated as electives to integrated MSc students at NISER for credit requirements for a minor in Computer Sciences.

1. CS456 Computational Geometry
2. CS457 Parameterized Algorithms
3. CS458 Approximation Algorithms
4. CS460 Machine Learning
5. CS461 Advanced Machine Learning
6. CS472 Introduction to Computational Number Theory
7. CS473 Advanced Computational Number Theory

The workload for each course is envisaged to be the following

Lectures and Tutorials	56 hours (3 Lectures and 1 Tutorial per week for 14 weeks).
Assignments, and problem solving	112 hours (8 hours per week for 14 weeks)
Exam preparation	30 hours
Exams	6 hours.

Total credit assigned for each course is 8. The courses were approved by the Academic Council of NISER. The details of the courses in the prescribed format are attached.

<u>Format for proposing approval of New Course or Revision of an existing course</u>

Course Title	**: Computational Geometry**
Course Level	**: 5 year Integrated M.Sc.**
Course Code	**: CS456**
Credits	**: 8 Credits**
Course Category	**: Elective**
Course Prerequisites	**: CS301**
Contact Hours (28/42/56) (including tutorials)	**: 56**
Proposed by	**: Aritra Banik and Sushmita Gupta**

The outcome of the Course:

- This course introduces students to the essentials of Computational Geometry and presents an in-depth study of the fundamental geometric structures and techniques used in this field.
- To learn advanced geometric algorithms, to deal with a large number of real-world problems from other fields such as Wireless and Mobile Computing, Computer Graphics, Computer Vision, Databases, Robotics, and VLSI design
- To be able to understand the complexity of geometric problems

Course Contents:

- Module 1: (3L+1T) Introduction to Computational Geometry, Convex hull algorithms
- Module 2: (3L+1T) Visibility Problems: Art gallery problem, Chvátal's art gallery theorem
- Module 3: (6L+2T) Dual Transformation and Applications: Intersection of Half Planes and Duality
- Module 4: (9L+3T) Range searching: Orthogonal range searching, Priority Search Trees, Non-Orthogonal Range Searching, Half-Plane Range Query
- Module 5: (9L+3T) Voronoi Diagram: Voronoi Diagram: Properties, Fortune's algorithm, Delaunay triangulation, Voronoi diagram in higher dimension
- Module 6: (9L+3T) Point Location and Triangulation: Planar Point Location, Point Location, and Triangulation, Triangulation of Arbitrary Polygon
- Module 7: (3L+1T) VC-dimension, Epsilon-nets: Epsilon-Nets and VC Dimension, Geometric Set Cover (with Bounded VC Dimension)

Text Books (if any) : NA

References

- Berg, M. D., Kreveld, M. V., Overmars, M., and Schwarzkopf, O., (2008), Computational Geometry: Algorithms and Applications, 3rd Edition, Springer
- Preparata, F., and Shamos, M., (1985), Computational Geometry: An Introduction, 1st Edition, Springer-Verlag
- Mulmuley, K., (1994), Computational Geometry: An Introduction Through Randomized Algorithms, 1st Edition, Prentice-Hall

Suggested References:
Relevant research articles with updates in knowledge as decided by the Instructor.

Format for proposing approval of New Course or Revision of an existing course

Course Title	**: Parameterized Algorithms**
Course Level	**: 5 year Integrated M.Sc.**
Course Code	**: CS457**
Credits	**: 8 Credits**
Course Category	**: Elective**
Course Prerequisites	**: CS202 and CS 301**
Contact Hours (28/42/56) (including tutorials)	**: 56**
Proposed by	**: Sushmita Gupta and Aritra Banik**

The outcome of the Course:

Students will be able to:

- Understand the algorithmic paradigm of parameterized complexity.
- To understand the hardness of parameterized problems.

Course Contents:

- Module 1 (3L+1T). Introduction to parameterized problems, parameterized algorithms, and parameterized hardness.
- Module 2 (3L+1T): The technique of bounded search tree.
  Module 3 (3L+1T). The technique of Iterative Compression.
- Module 4(3L+1T). Kernelization as a tool for polynomial-time preprocessing algorithms.
- Module 5 (9L+3T). Randomized techniques
- Module 6(9L+3T). Advanced algorithmic techniques: Matroids, Representative Sets, etc
- Module 7 (9L+3T). Parameterized hardness and W-hierarchy.
- Module 8 (3L + 1T) Lower bounds based on Exponential Time Hypothesis

Text Books (if any) : NA

References

- Cygan, M., Fomin, F.V., Kowalik, L., Lokshtanov, D., Marx, D., Pilipczuk, M., Pilipczuk, M., Saurabh, S., Parameterized algorithms, 2016, 1st Edition, Springer Nature
- Neidermeir, R., Invitation to fixed parameter algorithms, 2006, 1st Edition, OUP Oxford

- Downey, R., and Fellows, M., Fundamentals of parameterized complexity, 2013, 1st Edition, Springer Nature

Suggested References: Relevant research articles as decided by the Instructor.

Format for proposing approval of New Course or Revision of an existing course

Course Title	**: Approximation Algorithms**
Course Level	**: 5 year Integrated M.Sc.**
Course Code	**: CS458**
Credits	**: 8 Credits**
Course Category	**: Elective**
Course Prerequisites	**: CS301**
Contact Hours (28/42/56) (including tutorials)	**: 56**
Proposed by	**: Aritra Banik and Sushmita Gupta**

The outcome of the Course:

- Students will learn basic and advanced techniques to design efficient approximation algorithms.

Course Contents:

- Module 1: (3L+1T) Lecture 1: Introduction, the notion of approximation ratio
- Module 2: (6L+2T) Greedy and combinatorial methods
- Module 3: (6L+2T) Local search
- Module 4: (9L+3T) Dynamic programming and approximation schemes
- Module 5: (9L+3T) Linear programming rounding methods (randomized, primal-dual, dual-fitting, iterated rounding)
- Module 6: (6L+2T) Semi-definite program based rounding
- Module 7: (3L+1T) Metric methods

References

- The design of Approximation Algorithms, by David Williamson and David Shmoys, Cambridge University Press; 1st edition (2011)
- Approximation Algorithms, by Vijay Vazirani, Springer Nature (SIE) (2013)
- Approximation Algorithms for NP-hard Problems, edited by Dorit S. Hochbaum, Cambridge University Press; 1st edition (2011)

Text Books (if any) : NA

Suggested References:

Relevant research articles with updates in knowledge as decided by the Instructor.

<u>Format for proposing approval of New Course or Revision of an existing course</u>

Course Title	**: Algorithmic Game Theory**
Course Level	**: 5 year Integrated M.Sc.**
Course Code	**: CS459**
Credits	**: 8 Credits**
Course Category	**: Elective**
Course Prerequisites	**: CS202 and CS301**
Contact Hours (28/42/56) (including tutorials)	**: 56**
Proposed by	**: Sushmita Gupta and Aritra Banik**

The outcome of the Course:

Students will be able to:

- To understand the algorithmic techniques applied to problems in Game Theory.
- To understand the science of "rule-making", i.e Mechanism Design.
- To understand and design theoretical frameworks that model real life problems.

Course Contents:

- Module 1 (6L+2T). Introduction and Examples. Mechanism Design Basics. Algorithmic Mechanism Design.
- Module 2 (6L+2T) Introduction to Auctions. Revenue Maximizing, Near-Optimal Auction etc.
- Module 3 (3L+1T). Spectrum Auctions.
- Module 4 (6L+2T). Mechanism Design with Payment Constraints.
- Module 5 (3L+1T). Kidney Exchange and Stable Matching
- Module 5 (9L+3T). Selfish Routing and the Price of Anarchy
- Module 7 (3L+1T). Equilibria--Definitions, Examples and Existence
- Module 8 (6L+2T) Best-Case and Strong Nash Equilibria.

Text Books (if any) : NA

References

- Roughgarden, Twenty Lectures on Algorithmic Game Theory, 2016, 1st edition, Cambridge University Press
- Leyton-Brown, Essentials of Game Theory, 2008, 1st edition, Morgan & Claypool Publishers
- Yoav Shoham and Kevin Leyton-Brown, MULTIAGENT SYSTEMS Algorithmic, Game-Theoretic, and Logical Foundations, 2008, 1st edition, Cambridge University Press;
- David Manlove, Algorithmics of Matchings under Preferences, 2013, 1st edition, WSPC
- Brandt, Conitzer, Endriss, Lang, Procaccia, Handbook of Computational Social Choice, 2013, 1st edition, Cambridge University Press

Suggested References: Relevant research articles as decided by the Instructor.

<u>Format for proposing approval of New Course or Revision of an existing course</u>

Course Title : Machine Learning
Discipline : Computer Sciences
Course Level : 5 year Integrated M.Sc.
Course Code : CS460
Credits : 8 Credits
Course Category : Elective
Course Prerequisite : CS301 or equivalent
Contact Hours (28/42/56) (including tutorials) : 56

Proposed by : Subhankar Mishra and Rishiraj Bhattacharyya

Outcome of the Course:

- Students will be introduced to key concepts of machine learning.
- Understand and implement supervised, unsupervised learning algorithms as well as introduction to reinforcement learning.

Course Contents:

- Module 1 (9L + 3T): Introduction, Learning, Inductive bias, Features, Labels, Basics of statistics and probability
- Module 2(9L + 3T): Supervised learning: Linear Regression, Logistic regression. Perceptron. Naive Bayes, Support vector machines, Model selection and feature selection.,
- Module 3(9L + 3T): Ensemble methods: Bagging, boosting, Learning theory: Bias/variance tradeoff.
- Module 4(9L + 3T): Unsupervised learning: Clustering. K-means, EM. Mixture of Gaussians, Factor analysis, PCA (Principal components analysis), ICA (Independent components analysis).
- Module 5(6L + 2T): Reinforcement learning, Value iteration and policy iteration,

Text Books (if any): NA

Suggested References:

- Richard Duda, Peter Hart and David Stork, Pattern Classification, 2nd ed. John Wiley & Sons 2007
- Tom Mitchell, Machine Learning. McGraw-Hill, 1st Edition, 2017
- Richard Sutton and Andrew Barto, Reinforcement Learning: An introduction. MIT Press, 2nd Edition, 2018.
- The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Second Edition (Springer Series in Statistics), 9th printing 2017 edition

Format for proposing approval of New Course or Revision of an existing course

Course Title	**: Advanced Machine Learning**
Discipline	**: Computer Sciences**
Course Level	**: 5 year Integrated M.Sc.**
Course Code	**: CS461**
Credits	**: 8 Credits**
Course Category	**: Elective**
Course Prerequisite	**: CS460**
Contact Hours (28/42/56) (including tutorials)	**: 56**

Proposed by **: Subhankar Mishra and Rishiraj Bhattacharyya**

Outcome of the Course:

- The students will gain insight on multilayer neural networks.
- They will learn and implement Convolution Neural Networks and Recurrent Neural Networks which are currently widely used in images and natural language processing.
- They also would be learning generative adversarial networks.

Course Contents:

- Module 1(6L + 2T): Regression, classification, regularization, gradient descent
- Module 2(9L + 3T): Neural Networks - Multilayer perceptron, Backpropagation, TensorFlow
- Module 3(9L + 3T): Images - Deep Learning - Convolutional Neural Networks, motivation, architecture
- Module 4(9L + 3T): NLP - Recurrent neural networks, backpropagation through time, long short term memory, attention networks, memory networks
- Module 5(9L + 3T): Generative Models - Generative Adversarial Networks, Unsupervised learning, dimensionality reduction and visualization.

Text Books (if any): NA

Suggested References:

- Ian Goodfellow, Yoshua Bengio and Aaron Courville. Deep Learning. 1st Edition, MIT Press 2016
- Kevin P. Murphy. Machine Learning: A Probabilistic Perspective. 1st Edition, MIT Press 2012

<u>Format for proposing approval of New Course or Revision of an existing course</u>

Course Title : Introduction to Computational Number Theory
Discipline : Computer Sciences
Course Level : 5 year Integrated M.Sc.
Course Code : CS472
Credits : 8 Credits
Course Category : Elective
Course Prerequisite : CS301
Contact Hours (28/42/56): 56
(including tutorials)

Proposed by : Sabyasachi Karati, and Rishiraj Bhattacharyya

Outcome of the Course:

- Finding and implementing efficient computer algorithms for solving various problems in number theory.
- Numerous Applications to Algebraic coding theory, Cryptography and Computational complexity theory.

Course Contents:

- Module 1 (12L+4T). **Discrete Mathematical Structures:** Groups, Rings, Fields.
- Module 2 (12L+4T). **Algorithms for integer arithmetic:** Divisibility, GCD, modular arithmetic, modular exponentiation, Montgomery arithmetic, congruence, Chinese remainder theorem, Hensel lifting, orders and primitive roots, quadratic residues, integer and modular square roots, prime number theorem, continued fractions and rational approximations.
- Module 3 (9L+3T). **Representation of finite fields:** Prime and extension fields, representation of extension fields, polynomial basis, primitive elements, normal basis, optimal normal basis, irreducible polynomials.
- Module 4 (9L+3T). **Algorithms for polynomials:** Root-finding and factorization, Lenstra-Lenstra -Lovasz algorithm, polynomials over finite fields.

Text Books:

1. D. Dummit and R. Foote, *Abstract Algebra*, Wiley, 2011.
2. A. Das, *Computational Number Theory*, CRC Press, 2013, .
3. H Cohen, *A Course in Computational Algebraic Number Theory,* Springer, 2000
4. by R Lidl, H Niederreiter, *Introduction to Finite Fields and their Applications,* Cambridge University Press, 1997
5. S. Galbraith, *Mathematics of Public Key Cryptography*, 1st edition, 2011, Cambridge University Press.

6. I. Niven, H. S. Zuckerman and H. L. Montgomery, *An introduction to the theory of numbers*, 5th edition, 2008, Wiley.

Suggested References:

1. V. Shoup, *A computational introduction to number theory and algebra*, 2nd edition, 2008, Cambridge University Press.
2. M. Mignotte, *Mathematics for computer algebra*, 1st edition, 1992, Springer.
3. J. von zur Gathen and J. Gerhard, *Modern computer algebra*, 3rd edition, 2013, Cambridge University Press.
4. R. Lidl and H. Niederreiter, *Introduction to finite fields and their applications*, 2nd edition, 1994, Cambridge University Press.
5. Alfred J. Menezes, I. F. Blake, X-H Gao, R. C. Mullin, S. A. Vanstone and T. Yaghoobian, *Applications of finite fields*, 1st edition, 1993, Springer.
6. J. H. Silverman and J. Tate, *Rational points on elliptic curves*, 1st edition, 2010, Springer.
7. D. R. Hankerson, A. J. Menezes and S. A. Vanstone, *Guide to elliptic curve cryptography*, 1st edition, 2010, Springer.

Format for proposing approval of New Course or Revision of an existing course

Course Title : **Advanced Computational Number Theory**
Discipline : **Computer Sciences**
Course Level : **5 year Integrated M.Sc.**
Course Code : **CS473**
Credits : **8 Credits**
Course Category : **Elective**
Course Prerequisite : **CS472**
Contact Hours (28/42/56): 56
(including tutorials)
Proposed by : **Sabyasachi Karati, and Rishiraj Bhattacharyya**

Outcome of the Course:

- Finding and implementing efficient computer algorithms for solving various problems in number theory.
- Numerous Applications to Algebraic coding theory, Cryptography and Computational complexity theory.

Course Contents:

- **Elliptic curves:** The elliptic curve group, elliptic curves over finite fields, Schoof's point counting algorithm. **(12L + 2T)**
- **Primality testing algorithms:** Fermat test, Miller-Rabin test, Solovay-Strassen test, AKS test. **(7L + 1T)**
- **Integer factoring algorithms:** Trial division, Pollard rho method, *p*-1 method, CFRAC method, quadratic sieve method, elliptic curve method. **(10L + 1T)**
- **Computing discrete logarithms over finite fields:** Baby-step-giant-step method, Pollard rho method, Pohlig-Hellman method, index calculus methods, linear sieve method, Coppersmith's algorithm. **(12L + 1T)**
- **Applications:** Public Key Cryptography. **(8L + 2T)**

Text Books:

1. A. Das, *Computational Number Theory*, 1 edition, 2013, CRC Press.
2. S. Galbraith, *Mathematics of Public Key Cryptography*, 1 edition, 2011, Cambridge University Press.
3. I. Niven, H. S. Zuckerman and H. L. Montgomery, *An introduction to the theory of numbers*, 5th edition, 2008, Wiley.

Suggested References:

1. V. Shoup, *A computational introduction to number theory and algebra*, 2nd edition, 2008, Cambridge University Press.
2. M. Mignotte, *Mathematics for computer algebra*, 1st edition, 1992, Springer.
3. J. von zur Gathen and J. Gerhard, *Modern computer algebra*, 3rd edition, 2013, Cambridge University Press.
4. R. Lidl and H. Niederreiter, *Introduction to finite fields and their applications*, 2nd edition, 1994, Cambridge University Press.
5. Alfred J. Menezes, I. F. Blake, X-H Gao, R. C. Mullin, S. A. Vanstone and T. Yaghoobian, *Applications of finite fields*, 1st edition, 1993, Springer.
6. J. H. Silverman and J. Tate, *Rational points on elliptic curves*, 1st edition, 2010, Springer.
7. D. R. Hankerson, A. J. Menezes and S. A. Vanstone, *Guide to elliptic curve cryptography*, 1st edition, 2010, Springer.
8. H. Cohen, *Number Theory vol I,* Springer, 2008.
9. H. Lenstra, *Algorithms in Algebraic Number Theory*, https://www.math.leidenuniv.nl/~hwl/PUBLICATIONS/1992a/art.pdf
10. N. Koblitz, *A Course in Number Theory and Cryptography,* Springer, 1994.