# Indian Institute of Technology Mandi
## Proposal for a New Course

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| **Course Number** | : | MA 525 |
| **Course Name** | : | 3-0-0-3 |
| **Credits** | : | Heuristic Optimization |
| **Prerequisites** | : | IC150, IC111 or equivalent / instructor's consent. |
| **Intended for** | : | B.Tech. 3rd , 4th year, M.S./M.Tech./M.Sc., Ph.D. |
| **Distribution** | : | Elective |
| **Semester** | : | Odd/Even |

**Preamble :** In the last three decades heuristic optimization techniques have emerged as very effective alternative in solving many complex optimization problems that are difficult to solve by traditional optimization techniques. This course aims to provide a comprehensive background in the area of heuristic optimization. The course contains theoretical foundations and computational details of various algorithms. To enrich the learning of the students, implementation issues and their affect on the performance of various algorithms would be discussed with help of programming exercises.

At the end of the course, students are expected to present and submit a project report related to the problem assigned/chosen.

On completion of this course, the student are expected to

- as an user, to select the most adequate method for his/her problem at hand;
- as a researcher, to design an optimization method suitable for a given class of problems, and to perform fair comparisons.

**Course Modules with Quantitative Lecture Hours:**

**Module 1:** **Introduction:** Introduction to optimization, Local and Global Minima, Classical Optimization Techniques, Heuristic Optimization techniques. (2 lecture hours)

**Module 2:** **Random number generations:** Random numbers of a given distribution, properties and statistical tests. Simulation of random number generators. (4 lecture hours)

**Module 3:** **Benchmarks and algorithms comparisons:** Parameter settings and statistical criterion for comparison of various algorithms, parametric and non parametric tests, non statistical measures and (4 lecture hours)

issues with them.

**Module 4:** **Continuous Optimization:** Evolutionary Techniques, Swarm based Techniques and other nature inspired techniques. Theoretical foundations of various techniques. Implementation issues with various techniques and their comparisons based on benchmarks. (8 lecture hours)

**Module 5:** **Discrete and combinatorial Optimization:** Heuristic optimization approaches for discrete, mixed continuous discrete and combinatorial problems. Application to solve Knapsack, TSP, Network Flow problems, Submodular Functions under Matroid Constraints. (4 lecture hours)

**Module 6:** **Estimation of Distribution Algorithms:** EDA for discrete optimization and their comparisons, continuous EDA, Application of discrete and continuous EDA in optimization and machine learning. (4 lecture hours)

**Module 7:** **Hybrid techniques:** Local search methods and their advantages. Hybrid optimization techniques. Use of hybrid techniques and their application. (4 lecture hours)

**Module 8:** **Constraint handling techniques:** Problems with inequality and equality constraints. Methods based on rejection strategies, repair strategies, specialized operators. Penalty parameter based and penalty parameter less approaches. Approaches for handling equality constraints. Implementation of various constraint handling techniques and their comparison over various practical and benchmark problems. (6 lecture hours)

**Module 9:** **Multi objective optimization**: Various approaches to handle multiple objectives, Pareto Optimality. Dominance and decomposition based approaches. Hybrid techniques. Bi-level optimization. Theoretical Foundations and Applications to engineering and finance. (6 lecture hours)

**Textbooks:**


1. Engelbrecht, Andries P., *Fundamentals of computational swarm intelligence.* John Wiley & Sons, 2006.
2. Deb, K., *Multi-objective optimization using evolutionary algorithms.* John Wiley & Sons, 2001.


**Reference Books:**


1. Mezura-Montes, E. (Ed.), *Constraint-Handling in Evolutionary Optimization Constraint-Handling in Evolutionary Optimization*, Studies in Computational Intelligence, vol. 198, Springer-Verlag, 2009.
2. Eiben, A.E. and Smith, J.E., *Introduction to Evolutionary Computing*, Springer, Berlin, 2003.
3. Niederreiter, H. *Random number generation and quasi-Monte Carlo methods.* Society for Industrial and Applied Mathematics, 1992.
4. Coello, C. A. C., Lamont, G. B., and Veldhuizen, D. A. V., *Evolutionary algorithms for solving*

*multi-objective problems*. Vol. 5. Springer, 2007.

5. Datta, R., and Deb, K. (Eds.), *Evolutionary constrained optimization*. Springer, 2014.
6. Lobo, F. J., Lima, C. F., and Michalewicz, Z. (Eds.), *Parameter setting in evolutionary algorithms*. Vol. 54, Springer Science & Business Media, 2007.
7. Blum, C., Roli, A. and Sampels, M. (Eds.), *Hybrid metaheuristics: an emerging approach to optimization*. Springer, 2008.
8. Larrañaga, P. and Lozano, J. A. (Eds). *Estimation of distribution algorithms: A new tool for evolutionary computation*. Springer Science & Business Media, 2012.
9. Clerc, M., *Guided randomness in optimization*. Vol. 1. John Wiley & Sons, 2015.
10. Wolsey, L. A., and Nemhauser, G. L., *Integer and Combinatorial Optimization*, Wiley, 1999.
11. Zbigniew M. and Fogel, D., *How to Solve it: Modern Heuristics*, Springer Verlag, 2000.

**Similarity content declaration with existing courses:**

| Sl. No. | Course Code | Similarity Content | Approximate % of Content |
|---|---|---|---|
| 1. | MA 651 | Evolutionary Optimization Techniques (Binary Genetic Algorithms) | <10% |

**Justification for new course proposal if cumulative similarity content is > 30%:**
Not Applicable.

**Approvals:**

Other faculty interested in teaching this course: Dr. Samar
Proposed by: Dr. Manoj Thakur

School: School of Basic Sciences (SBS)

Signature: Date: 06-11-2017

**Recommended / Not Recommended, with comments:**

Chairman, CPC Date:

Approved / Not Approved:

Chairman, Senate Date: