Indian Institute of Technology, Kanpur
Proposal for a New Course

1. Course No: SPAMXXX

2. Course Title: Statistical Methods and Applications

3. Lectures per week: 2 (L), Tutorial: 0 (T), Laboratory: 1 (P), Additional hours: (0-2): 0 (A), Credits (3*L+2*T+P+A): 5,
   Duration of Course: Half Semester Modular Course

4. Proposing Department: Space Science & Astronomy

5. Proposing Instructor: Rohit Sharma

6. Course Description

   (A) Objectives: The course aims to introduce students to basics of statistical techniques, and some application used in astronomy and space physics. Initial course time is devoted to understanding and revision of basics followed by most used statistical techniques and data science. This course will be directed towards building a base for more advanced astronomy oriented data science applications.

   (B) Contents:

   1. **Introduction to Multivariate Calculus** (1 lecture)
      Partial derivative, Gradients, Linearization of functions, Taylor Series approximation
   2. **Probability & Distribution** (3 lectures)
      Discrete Probability, Probability distribution & properties, Central limit theorem, K-S test, Bayes Theorem and inference with application to single variable model
   3. **Uncertainty & Error Propagation** (6 lectures)
      random variables, standard error, variance, moments, noise: random & systematic, accuracy and precision, correlations & applications, Fisher Matrix & Covariance Matrix
   4. **Numerical methods for Parameter Estimation Techniques** (6 lectures)
      minima and maxima, critical points, convexity, χ^2 estimation, constrained optimization, linear regression, Maximum likelihood estimators & examples, Priors & Posteriors
   5. **Examples of Application to Astronomy Data** (2 lectures)
      Different astronomical datasets will be complied for this exercise
   6. **Modern trends** (3 lectures)
      Monte-Carlo-Markov Chain simulations, K-means, Gaussian Mixtures etc..

   (C) Pre-requisites, if any: N/A

   (D) Short summary for including in the Courses of Study Booklet: Statistical Methods / Techniques- Probability, distributions, error propagation, numerical optimization, regression, priors and posteriors, expectation-maximisation, applications to data science Commonality between topics will be taught.

7. Recommended Books:

   - Statistics (4th Edition)
     Authors: David Freedman, Robert Pisani, Roger Purves
   - Practical Optimization
     Authors: Andreas Antoniou and Wu-Sheng Lu
   - Doing Bayesian Data Analysis (2nd Edition)
     Author: John K. Kruschke

8. Any other remarks:

Dated: Proposer:

Dated: DUGC/DPGC Convener:

The course is approved/not approved

Chairman, SUGC/SPGC

Dated: