Estd. 1962
"A++" Accredited by NAAC (2021)
With CGPA 3.52

SHIVAJI UNIVERSITY, KOLHAPUR - 416004, MAHARASHTRA
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शिवाजी विद्यापीठ, कोल्हापूर -४१६००४,महाराष्ट्र
दूरध्वनी-ईपीएबीएक्स -२६०९०००, अभ्यासमंडळे विभाग दुरध्वनी ०२३१—२६०९०९४
०२३१—२६०९४८७

SU/BOS/Science/473 **Date: 19/08/2024.**

To,

The Principal, All Concerned Affiliated Colleges/Institutions Shivaji University, Kolhapur	The Head/Co-ordinator/Director All Concerned Department (Science) Shivaji University, Kolhapur.

Subject: Regarding Minor Change syllabi of M.Sc. Part-I & II as per NEP-2020 (2.0) degree programme under the Faculty of Science and Technology.

Ref: SU/BOS/Science/482 Date: 01/07/2023 & 09 Date: 02/01/2024

Sir/Madam,

With reference to the subject mentioned above, I am directed to inform you that the university authorities have accepted and granted approval to the Minor Change in syllabi, nature of question paper and equivalence of M.Sc. Part-I & II as per NEP-2020 (2.0) degree programme under the Faculty of Science and Technology.

M.Sc. Part-I & II as per NEP-2020 (2.0)			
1.	Statistics	2.	Applied Statistics and Informatics

This syllabus, nature of question shall be implemented from the academic year 2024-2025 onwards. A soft copy containing the syllabus is attached herewith and it is also available on university website www.unishivaji.ac.in,NEP-2020@suk(Online Syllabus).

The question papers on the pre-revised syllabi of above-mentioned course will be set for the examinations to be held in October /November 2024 & March/April 2025. These chances are available for repeater students, if any.

You are, therefore, requested to bring this to the notice of all students and teachers concerned.

Thanking you,

Dy Registrar
Dr. S. M. Kubal

Copy to:

1	The Dean, Faculty of Science & Technology	4	P.G Admission / Eligibility Section
2	The Chairman, Respective Board of Studies	5	Computer Centre/ Eligibility Section
3	B.Sc. Exam/ Appointment Section	6	Affiliation Section (U.G.) (P.G.)

SHIVAJI UNIVERSITY, KOLHAPUR

Established: 1962

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Structure and Syllabus in Accordance with

National Education Policy – 2020 (NEP 2.0)

with Multiple Entry and Multiple Exit

of

Master of Science (Applied Statistics and Informatics) Part II

under
Faculty of Science and Technology

(To Be Implemented From Academic Year 2024-25)

Courses

M.Sc. Semester-III			
Sr. No.	**Course Category**	**Course Title**	**Course Code**
1	Major Mandatory	Stochastic Processes	MSU0325MML905I1
2		Theory and Practice of Machine Learning	MSU0325MML905I2
3		Multivariate Analysis	MSU0325MML905I3
4		Practical-III	MSU0325MMP905I4
5	Major Elective*	Data Base Management System	MSU0325MEL905I1
6		Statistical Programming using SAS	MSU0325MEL905I2
7		Artificial Intelligence	MSU0325MEL905I3
8	Research Project	Research Project	MSU0325RPP905I
M.Sc. Semester-IV			
Sr. No.	**Course Category**	**Course Title**	**Course Code**
1	Major Mandatory	Biostatistics	MSU0325MML905J1
2		Time Series Analysis	MSU0325MML905J2
3		Practical-IV	MSU0325MMP905J3
4	Major Elective*	Advanced Topics in Artificial Intelligence	MSU0325MEL905J1
5		Marketing and Financial Analytics	MSU0325MEL905J2
6		Analysis of Big Data	MSU0325MEL905J3
7	Research Project	Research Project	MSU0325RPP905J

*Only one course under this category is to be chosen by the student.

M. Sc. Applied Statistics and Informatics (Part II) (Level-6.5) (Semester III) (NEP-2020)

Title of Course: Stochastic Processes
Course Code: MSU0325MML905I1
Total Credits: 04
Course outcomes:
Upon successful completion of this course, the students will be able to:

1. Identify appropriate stochastic process model for a given real life process.
2. Specify a given discrete time Markov chain in terms of a transition probability matrix and a transition diagram, and calculate higher step transition probabilities and limiting probabilities.
3. Understand and analyses discrete state space continuous time Markov chains and their practical applications
4. Explore the Galton-Watson Binary Branching process and understand the fundamental elements of Queuing models

Unit 1: Definition of stochastic process, classification of stochastic processes according to state space and time domain, finite dimensional distributions. Examples of various stochastic processes. Definition of Markov chain. Examples of Markov chains, Formulation of Markov chain models, initial distribution, transition probability matrix, Chapman-Kolmogorov equations, calculation of n-step transition probabilities. Simulation of Markov Chain.

(12L +3T)

Unit 2: Classification of states, irreducible Markov chain, period of the state, random walk and gambler's ruin problem, first entrance theorem, first passage time distribution. Long-Run proportions and limiting probabilities, relation with mean recurrence time, stationary distribution.

(12L +3T)

Unit 3: Discrete state space continuous time Markov chain, Poisson process and related results. Birth and death processes and associated cases. Renewal and delayed renewal processes, related theorems, key renewal theorem (Without proof) and its application. Simulation of Poisson process and discrete state space Markov processes.

(12L +3T)

Unit 4: Galton-Watson Binaymi Branching process. Generating functions and its properties, moments. Probability of ultimate extinction. Distribution of population size and association results. Simulation of branching process. Basic elements of Queuing model. Steady state probabilities and various average characteristics for the models: M/M/1, M/M/1 with balking, M/M/c and M/G/1.

(12 L+ 3T)

References:

1. Bhat B. R. (2000). Stochastic Models: Analysis and Applications, (New Age International)
2. Cinlar E. (2013): Introduction to Stochastic Process. (Courier Corporation)
3. Feller W.(2008): An Introduction to Probability Theory and Its Applications. (Wiley)
4. Hoel P. G., Port S. C. and Stone C. J. (1987): Introduction to Stochastic Processes. (Waveland Press)
5. Karlin S. and Taylor H. M. (1968): A First Course in Stochastic Process. (Academic Press)
6. Medhi J. (2009): Stochastic Process, (New Age International Publications)
7. Ross S. (1996): Stochastic Processes. (Wiley)
8. Ross S. (2014): Introduction to Probability Models. (Academic Press)
9. Taylor H. M. and Karlin S. (2014): An Introduction to Stochastic Modeling (Academic Press)

Title of Course: Theory and Practice of Machine Learning
Course Code: MSU0325MML905I2
Total Credits: 04
Course outcomes:
Upon successful completion of this course, the students will be able to:

1. Explain supervised learning and construct classifiers namely, decision tree, k-nearest neighbour(s), logistic regression, naïve Bayes, Bayesian Belief Network
2. Compare different classifiers and employ techniques to improve their performance.
3. Use Artificial Neural Network and Support Vector Machine for classification and prediction.
4. Apply clustering techniques and generate association rules using apriori algorithm.

Unit 1: Data understanding and data cleaning, concept of supervised and unsupervised learning. Problem of classification, classification techniques: k-nearest neighbor, decision tree, Naïve Bayesian, classification based on logistic regression, Bayesian belief Network.

(12L+3T)

Unit 2: Model evaluation and selection: Metrics for Evaluating Classifier Performance, Holdout Method and Random Subsampling, Cross-Validation, Bootstrap, Model Selection Using Statistical Tests of Significance, Comparing Classifiers Based on Cost–Benefit and ROC Curves. Techniques to Improve Classification Accuracy: Introduction to Ensemble Methods, Bagging, Boosting and AdaBoost, Random Forests, Improving Classification Accuracy of Class-Imbalanced Data.

(12L+3T)

Unit 3: ANN and SVM: Artificial Neutral Network (ANN): Introduction to ANN, types of activation functions: identity, sigmoid, double sigmoid, tanh, softmax, loss functions: squared error, cross entropy; optimizers: gradient decent, stochastic and minibatch gradient decent; McCulloch-Pitts AN model, single layer network, multilayer feed forward network model, training methods, ANN & regression models. Support vector machine: Introduction to support vector machine, loss functions, soft margin, optimization hyperplane, support vector classification, support vector regression, linear programming support vector machine for classification and regression.

(12L+3T)

Unit 4: Unsupervised learning: Clustering: k-mediods, CLARA, DENCLUE, DBSCAN, Probabilistic model based clustering. Market Basket Analysis: Association rules and prediction, Apriori Algorithm, data attributes, applications to electronic commerce.

(12L+3T)

References:

1. Berson and Smith S.J. (1997) : Data warehousing, Data Mining, and OLAP, McGraw-Hill.
2. Breiman J.H Friedman, R.A. Olshen and stone C.J. (1984) : Classification and Regression Trees, Wadsworth and Brooks / Cole.
3. Han, J. and Kamber, M. and Pei, J. (2012) : Data Mining: Concepts and Techniques. MorganGaufmann.3rd Edition.
4. Mitchell T.M. (1997) : Machine Learning , McGraw-Hill.
5. Ripley B.D. (1996) : Pattern Recognition and Neural Networks. Cambridge University Press.
6. Vapnik V.N. The nature of Statistical learning theory, Springer.
7. Cristianini N. and Shawe-Taylor J. An Introduction to support vectormachines.
8. Data set source: http://www.ICS.uci.edu/~mlearn/MLRepository.html
9. Mehrika, K., Mohan, C., and Ranka (1997) Elements of Artificial neural networks. Penram international.
10. Hastie T, Tibshirani R, Friedmant J, (2009): The elements of statistical Learning, Springer.
11. Chattamvelli, R. (2015). Data mining methods. Alpha Science International.

Title of Course: Multivariate Analysis
Course Code: MSU0325MML905I3
Total Credits: 02
Course outcomes:
Upon successful completion of this course, the students will be able to:

1. Perform exploratory multivariate data analysis, understand and apply discrimination and classification techniques and apply hierarchical and non-hierarchical clustering techniques
2. Understand and apply the Canonical Correlation Analysis, principal component analysis and factor analysis.

Unit 1: Exploratory multivariate data analysis, sample mean vector, sample dispersion matrix, correlation matrix, graphical representation, Partial and multiple correlation coefficients. Discrimination and classification: Fisher's discriminant function and likelihood ratio procedure, minimum ECM rule, Rao's U statistics and its use in tests associated with discriminant function, classification with three populations. Cluster analysis, Hierarchical methods: Single, Complete, average linkage method and non-hierarchical clustering method: k-means clustering.

(12L+3T)

Unit 2: Canonical correlation analysis: Introduction, canonical variates and canonical correlation, interpreting population canonical variables, sample canonical variates and sample canonical correlations; Principal component analysis: Introduction, Population principal components, summarizing sample variation by principal components, Graphing the principal components, large sample inferences; Factor analysis: Introduction, Orthogonal factor model, methods of estimation, factor rotation and factor score

(12L+3T)

References:

1. Kshirsagar A. M.(1972) : Multivariate Analysis. Marcel-Dekker.
2. Johnson, R.A. and Wichern . D.W (2002) : Applied multivariate Analysis. 5th Ad.Prentice – Hall.
3. Anderson T. W. (1984) : An introduction to Multivariate statistical Analysis 2nd Ed. John Wiely.
4. Morrison D.F. (1976) : Multivariate Statistical Methods McGraw-Hill.
5. Bhuyan K. C. (2005): Multivariate Analysis and its applications, New central book agency Ltd. Kolkatta.

Title of Course: Data Base Management System
Course Code: MSU0325MEL905I1
Total Credits: 04
Course outcomes:
Upon successful completion of this course, the students will be able to:

1. Understand and express the fundamental concepts of database.
2. Develop proficiency in designing and interpreting Entity-Relationship (ER) models, applying constraints, and addressing issues related to weak entity sets.
3. Master the basics of SQL and some of the advanced SQL queries
4. Familiar with the basic issues of transaction processing and concurrency control.

Unit 1: Introduction to Databases and Data Models: Concept of database system, purpose of database system, view of data, different sources of databases, relational databases, database architecture, importance of data models, basic building blocks, business rules, the evolution of data models, data abstraction, database users and administrators. Database design and ER Model: Overview, ER-Model, Constraints, ER-Diagrams, ERD issues, weak entity sets

(12L+3T)

Unit 2: Codd's rules, relational schema, introduction to UML relational database model: logical view of data, keys, and integrity rules. Relational Database design: features of good relational database design, atomic domain and normalization (1NF,2NF,3NF, BCNF). Relational algebra: Introduction of RDBMS, Selection and projection, set operations, renaming, Joins, Division, syntax, semantics. Operators, grouping and ungrouping, relational comparison. Calculus: tuple relational calculus, Domain relational Calculus, calculus vs algebra, computational capabilities.

(12L+3T)

Unit 3: Constraints: Concept and types of constrains. Views: Introduction to views, data independence, security, updates on views, comparison between tables and views. SQL: Basics of SQL, DDL, DML, DCL, structure: creation and alteration, defining constraints: primary key, foreign key, unique, not null, check, IN operator, Functions: aggregate functions, built-in functions, numeric, date, string functions, set operations, sub-queries, correlated sub- queries, use of group by, having, order by, join and its types, exist, any, all, view and its types joined relations, Triggers.

(12L+3T)

Unit 4: Transaction management: ACID properties, serializability and concurrency control, lock based concurrency control (2PL, Deadlocks), time stamping methods, optimistic methods, database recovery management, data dictionary. NoSQL: Overview, and history of NoSQL databases, definition of the four types of NoSQL database, introduction to Big Data.

(12L+3T)

References:

1. Abraham Silderschutz, H. Korth and S. Sudarshan: "Database systems concepts ",6th Edition, McGraw Hill Education
2. Peter Rob, Carlos Coronel: Database Systems: Design, Implementation, &Management.
3. Oracle installation and user manual
4. Ivan Bayross: SQL, PL/SQL The programming language of oracle, 4th edition, BPB publication
5. R. Elmasri, S. B. Navate: "Fundamentals of Database Systems", 6th Edition, Pearson.

Title of Course: Practical III
Course Code: MSU0325MMP905I4
Total Credits: 04
Course outcomes:
Upon successful completion of this course, the students will be able to:

1. Perform computations related to stochastic processes.
2. Study various stochastic processes through simulation.
3. Apply Machine Learning techniques to real data sets.
4. Analyze multivariate data using statistical software.

List of the practicals:

1. Simulation of Markov Chain
2. Computations on Markov Chain
3. Classification of Markov Chain
4. Stationary distribution of Markov Chain and its applications
5. Simulation of discrete time continuous state space stochastic processes
6. Supervised learning: Classification
7. Supervised learning: Prediction
8. Artificial neural network
9. Unsupervised learning
10. Association rule mining
11. Exploratory Multivaraite Data Analysis
12. Application of Discriminant Analysis and Cluster Analysis
13. Application of Principal Component Analysis
14. Application of Factor Analysis
15. Application of canonical correlation Analysis

16-20: Five practicals on the elective course

M. Sc. Applied Statistics and Informatics (Part II) (Level-6.5) (Semester IV) (NEP-2020)

Title of Course: Biostatistics
Course Code: MSU0325MML905J1
Total Credits: 04
Course outcomes:
Upon successful completion of this course, the students will be able to:

1. Explain the need, ethics, and various concepts in clinical trials.
2. Design and perform various phases of clinical trials.
3. Analyze Phase I-III bio-equivalence trials, case-control and cohort designs.
4. Explain the concept of censoring, various types of censoring, and perform inference about survival function.

Unit 1: Introduction to clinical trials: aim, need and ethics of clinical trials, conduct of clinical trials, preclinical research, phase I-IV trials, multi-center trials, bias and random error in clinical studies, randomization, blinding/masking in clinical trials, data management: data definitions, case report forms, database design, data collection systems for good clinical practice.

(12L+3T)

Unit 2: Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. longitudinal designs, factorial designs, objectives and endpoints of clinical trials, design of Phase I trials, design of single-stage and multi-stage Phase II trials, design, and monitoring of Phase III trials with sequential stopping.

(12L+3T)

Unit 3: Bioavailability, pharmacokinetics, and pharmaco-dynamics. Design of bio-equivalence trials, Decision rules for bioequivalence, Inference for 2x2 crossover design: Classical methods of interval hypothesis testing for bioequivalence, Bayesian methods, nonparametric methods, assessment of Inter-and Intra-subject variability, drug interaction studies, reporting and analysis: analysis of categorical outcomes from Phase I - III trials. Epidemiological studies: case-control and cohort study designs. Measures of disease occurrence and association.

(12L+3T)

Unit 4: Introduction to survival analysis, examples of survival data/time to event data, measurement of survival time, concept of censoring, various types of censoring, type-I, type-II, random censoring, likelihood constructions and ML estimation. Non parametric estimation of survival function: Actuarial Estimator, Kaplan Meier product limit estimator, non parametric estimates of the mean, median and percentiles of the survival times; Nelson Aalen estimator, non parametric tests for two-sample problem: Gehen test, Log rank test, Mantel Haenszel test. Cox proportional hazard regression model.

(12L + 2T)

References:

1. Chow, S. C., & Liu, J. P. (2008). *Design and analysis of clinical trials: concepts and methodologies* (Vol. 507). John Wiley & Sons.
2. Clayton, D., & Hills, M. (2013). *Statistical models in epidemiology*. OUP Oxford.
3. Collett, D. (2023). *Modelling survival data in medical research*. CRC press.
4. Daniel, W. W., & Cross, C. L. (2018). *Biostatistics: a foundation for analysis in the health sciences*. Wiley.
5. Deshpande, J. V., & Purohit, S. G. (2015). *Lifetime Data: Statistical Models and Methods* (Vol. 16). World Scientific Publishing Company.
6. Fleiss, J. L. (2011). *Design and analysis of clinical experiments*. John Wiley & Sons.
7. Friedman, L. M., Furberg, C. D., DeMets, D. L., Reboussin, D. M., & Granger, C. B. (2015). *Fundamentals of clinical trials*. springer.
8. Hosmer Jr, D. W., Lemeshow, S., & May, S. (2011). *Applied survival analysis: regression modeling of time-to-event data*. John Wiley & Sons.

9. Jennison, C., & Turnbull, B. W. (1999). *Group sequential methods with applications to clinical trials*. CRC Press.
10. Marubeni .E. and Valsecchi M. G. (1994). *Analyzing Survival Data from Clinical Trials and Observational Studies*. Wiley.
11. Miller R. G. (1981). *Survival Analysis*, McFraw-Hill, New York.
12. Piantadosi, S. (2017). *Clinical trials: a methodologic perspective*. John Wiley & Sons.

Title of Course: Time Series Analysis
Course Code: MSU0325MML905J2
Total Credits: 04
Course outcomes:
Upon successful completion of this course, the students will be able to:

1. Understand the time series; understand the concept of stationarity to the analysis of time series data in various contexts (such as actuarial studies, climatology, economics, finance, geography, meteorology, political science, and sociology).
2. Identify and isolate non deterministic components of observed time series; learn to translate an observed non-stationary series to stationary time series using an appropriate transformation.
3. Model, estimate, interpret and forecast observed time series through ARMA, ARIMA and SARIMA approach and Perform residual analysis for checking model adequacy.
4. Learn basics of time dependent volatility in time series, basics of ARCH and GARCH time series heteroscedastic models and basic of multivariate time series and its modeling

Unit 1: Exploratory time series analysis, Exponential, Double exponential and Holt-Winter smoothing and forecasting, auto-covariance, auto-correlation functions and their properties and characterization (without proof), partial auto covariance function, auto-covariance generating function. Weak and strong stationary time series, white noise process, Linear Process, estimates of mean, auto-covariance, auto-correlation and partial auto-covariance functions.

(12 L + 3 T)

Unit 2: Wold representation of linear stationary processes, linear time series models: autoregressive(AR), moving average(MA), autoregressive moving average models (ARMA). causality and invertibility of ARMA processes, computation of π -weights and ψ- weights, computation of ACVF, ACF and PACF for AR(1), AR(2), MA(1), MA(2), ARMA(1,1) processes and general procedure for ARMA(p,q) process. The need for differencing a time series, autoregressive integrated moving average models(ARIMA).

(12 L + 3 T)

Unit 3: Estimation of ARMA models: Yule-Walker estimation for AR Processes, Maximum likelihood and least squares estimation for ARMA Processes, Residual analysis and diagnostic checking. Minimum mean squared error forecasting for ARMA and ARIMA models, updating forecasts. Introduction to SARIMA models, Spectral Representation of the ACVF, Spectral density of an ARMA process, its computation for simple models.

(12 L + 3 T)

Unit 4: Introduction to ARCH and GARCH models. Properties and estimation under ARCH(1) and GARCH(1,1) model. Vector time-series models: Covariance and Correlation Matrix functions, MA and AR representation of vector processes, Covariance matrix function of the vector AR(1) and MA(1) models.

(12L + 3T)

Reference:

1. Box, G. E., Jenkins, G. M., Reinsel, G. C., & Ljung, G. M. (2015). *Time series analysis: forecasting and control*. John Wiley & Sons.
2. Brockwell, P. J., & Davis, R. A. (2009). *Time series: theory and methods*. Springer science & business media.
3. Chatfield, C. (2004) *The Analysis of Time Series - An Introduction*, Sixth edition, Chapman and Hall.
4. Kendall, M.G. (1978) *Time Series*, Charler Graffin
5. Tsay, R. S. (2005). *Analysis of financial time series*. John wiley & sons.
6. WEI, W. W. (2006). *Time Series Analysis: Univariate and Multivariate Methods*.

Title of Course: Advanced Topics in Artificial Intelligence
Course Code: MSU0325MEL905J1
Total Credits: 04
Course outcomes:
Upon successful completion of this course, the student will be able to:

1. Explain the concept of deep learning and apply deep learning algorithms for modelling of real world data using Python
2. Acquire the fundamental concepts of image processing and apply those for analyzing real world images using Python
3. Use NLP methods to explore and gain a broad understanding of text data using Python
4. Understand the concept of generative artificial intelligence and develop applications based on it.

Unit 1: Overview of neural Network concept, optimizers: Gradient Descent (GD) with momentum NAG, GD with adaptive learning rates: AdaGrad, RMSProp, Adam; introduction to deep learning, understanding different types of layers in sequential method: Dense, Convolutional Layers, Recurrent Layers, Normalization Layers. Deep Neural Network architecture design, optimization for Deep NN, regularization methods for deep NN, Convolutional Neural Network (CNN), Recurrent Neural Network (RNN), Long Short Term Memory (LSTM), Deep learning Python libraries: tensorflow (Low level) and Keras (High Level).

(12L+3T)

Unit 2: Introduction to Natural Language Processing (NLP), Natural Language Toolkit (NLTK) in Python. Data Preparation: punctuation removal, stop-words removal, numeric value removal, frequent words removal, rare words removal, spelling correction, tokenization, stemming, lemmatization. Feature Engineering:count vectors as features, Term Frequency-Inverse Document Frequency (TF-IDF), TF-IDF vectors as features, word level TF-IDF, N-Gram level TF-IDF, Character level TF-IDF, world cloud, Inverse Document Frequency, word embedding as features, Text/NLP based features, Topic Models as features, word2vec, sentiment analysis.

(12L+3T)

Unit 3: Computer vision: Introduction, OpenCv library in Python, Getting Started with images, Basic Operations on Images, Arithmetic Operations on Images,Image Pre-processing: changing colorspaces, geometric transformations, thresholding, smoothing, morphological transformations, gradients, Canny Edge detection, image pyramids, image segmentation with Watershed algorithm, Feature Detection and Description. Image Detection and recognition examples.

(12L+3T)

Unit 4: Introduction to Generative Artificial Intelligence (AI). Understanding generating AI and the difference from discriminative models. Fundamentals of Generative Models: Overview of Generative Adversarial Networks (GANs), Variational Autoencoders (VAEs), and Boltzmann machine, including working principle and applications. GANs: In-depth study, including generator and discriminator networks, data generation, training challenges, and applications. VAEs: Exploring concepts of encoder and decoder networks, latent space, training process, and real-world applications. Large Language Models (LLMs): Introduction to GPT and Bidirectional Encoder Representations from Transformers (BERT), architectural design, training process, transfer learning in NLP, advantages and limitations. Ethical Considerations: Ethical implications in generative AI – such as deepfakes, privacy concerns, and data bias.

(12L+3T)

References:

1. Bird, S., Klein, E., & Loper, E. (2009). *Natural language processing with Python: analyzing text with the natural language toolkit.* " O'Reilly Media, Inc.".
2. Goodfellow, I. (2016). Nips 2016 tutorial: Generative adversarial networks. *arXiv preprint arXiv:1701.00160*.
3. Goodfellow, I., Bengio, Y., Courville, A., &Bengio, Y. (2016). *Deep learning (Vol. 1).* Cambridge: MIT press.

4. Hardeniya, N., Perkins, J., Chopra, D., Joshi, N., &Mathur, I. (2016). *Natural Language Processing: Python and NLTK.* Packt Publishing Ltd.
5. Mueller, J. P., &Massaron, L. (2015). *Python for data science for dummies.* John Wiley & Sons.
6. Shanmugamani R. (2018). *Deep Learning for Computer Vision: Expert techniques to train advanced neural networks using TensorFlow and Keras.* "Packt Publishing Ltd"
7. Solem, J. E. (2012). *Programming Computer Vision with Python: Tools and algorithms for analyzing images.* " O'Reilly Media, Inc.".

Title of Course: Practical IV
Course Code: MSU0325MMP905J3
Total Credits: 04
Course outcomes:
Upon successful completion of this course, the students will be able to:

1. Analyze data generated in clinical trials.
2. Perform parametric and non-parametric analysis of survival data.
3. Model and analyze various time series data.
4. Use statistical software for analysis.

List of practicals

1. Pharmacokinetic Parameters
2. Statistical Methods for Bioequivalence
3. Epidemiology
4. Parametric Analysis of Survival Data
5. Non parametric analysis of survival data
6. Cox-proportional hazard model
7. Exploratory analysis of time series data
8. smoothing time series data and forecasting
9. Modeling and analysis of univariate time series.
10. Modeling and analysis of Heteroscedastic time series.
11. Modeling and analysis of time series.

12-16: five practicals on the elective course

Equivalence of courses

M. Sc. Part II (Semester III and IV)

Old Course				Equivalent Course		
Sem No.	**Course Code**	**Title of Old Course**	**Credit**	**Course code**	**Title of New Course**	**Credit**
III	CC-301	Data Base Management System	4	MSU0325MEL905I1	Data Base Management System	4
III	CCS-302	Multivariate Analysis	4	No equivalence can be given for these courses in the new syllabus as per NEP 2020		
III	CCS-302	Bayesian Inference	4			
III	CCS-303	Stochastic Processes	4	MSU0325MML905I1	Stochastic Processes	4
III	CCS-303	Functional Data Analysis	4	No equivalence can be given for these courses in the new syllabus as per NEP 2020		
III	CCS-304	Data Mining	4	MSU0325MML905I2	Theory and Practice of Machine Learning	4
III	CCS-304	Artificial Intelligence	4	MSU0325MEL905I3	Artificial Intelligence	4
III	DSE-305	Time series analysis	4	MSU0325MML905J2	Time series analysis	4
III	DSE-305	Statistical ecology	4	No equivalence can be given for these courses in the new syllabus as per NEP 2020		
III	CCPR-306	Practical III	4	MSU0325MMP905I4	Practical III	4
IV	CC-401	Generalized Linear Model	4	No equivalence can be given for these courses in the new syllabus as per NEP 2020		
IV	CCS-402	Survival Analysis	4			
IV	CCS-402	Actuarial Statistics	4	MSU0325MEL937J4	Actuarial Statistics	4
IV	CCS-403	Biostatistics	4	MSU0325MML905J1	Biostatistics	4
IV	CCS-403	Econometrics	4	No equivalence can be given for these courses in the new syllabus as per NEP 2020		
IV	CCS-404	Python for Data Science	4	MSU0325MEL905J1	Advanced Topics in Artificial Intelligence	4
IV	DSE-405	Spatial data Analysis	4	No equivalence can be given for these courses in the new syllabus as per NEP 2020		
IV	DSE-405	Statistical Quality Control	4			
IV	CCPR-406	Practical IV and Project	4	MSU0325MMP905J3	Practical IV	4