Tribhuvan University

Institute of Science and Technology
SCHOOL OF MATHEMATICAL SCIENCES
Syllabus
Master's in Data Sciences (MDS)- FOURTH SEMESTER

Compulsory Courses

Course Code	Course Titles	Credits	Nature
MDS 651	Data Visualization	3	Th.
MDS 652	Capstone Project / Thesis	6	Project + Report

Elective Courses (Any Two)

Course Code	Course Titles	Credits	Nature
MDS 653	Social Network Analysis	3	Th.+ Pr.
MDS 654	Actuarial Data Analysis	3	Th.+ Pr.
MDS 655	Deep Learning	3	Th.+ Pr.
MDS 656	Business Analytics	3	Th.+ Pr.
MDS 657	Bioinformatics	3	Th.+ Pr.
MDS 658	Economic Analysis	3	Th.+ Pr.

Code No.: MDS 651
Course Title: Data Visualization   **Full Marks: 75**
Nature: Theory (Compulsory)   **Credit: 3**

*Course Description***:**
This course presents comprehensive introduction to several topics on data visualization and its application. It provides the board overview of techniques of the visualization process, detailed view of visual perception, the visualized data and the actual visualization, interaction and distorting techniques.
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Learning Objectives:
Upon the completion of this course, students should be able to:
● Explain the concept of visualization in the processing and analysis of data.

● Understand and apply visualization models

● Implement attribute and spatial data visualization and applications

● Implement text and document visualization

●. Evaluate visualization techniques and explain its isuues

*Course Contents***:**

Unit 1: Introduction   [6 Hrs.]

Introduction of visual perception, Visual representation of data, Data   abstraction, Visual encodings, Use of color, Perceptual issues, Information overloads

Unit 2: Visual Representations   [6 Hrs.]

Visualization reference model, Visual mapping, Visual analytics, Design of visualization applications.

Unit 3: Attribute Data Visualization   [12 Hrs.]

Visualization of one, two and multi-dimensional data, Tabular data, quantitative values (scatter plot), Separate, Order and align (Bar, staked bar, dots and line charts), Tree data, Displaying Hierarchical structures, Graph data, Rules for graph drawing and labeling, Time series data, Characteristics of time data, Visualization time series data, Mapping of time.

Unit 4: Spatial Data Visualization   [8 Hrs.]

Scalar fields**,** Isocontours (Topographic Terrain maps), scalar volumes**,** Direct volume Rendering (Multidimensional transfer functions), Maps (dot, pixel), vector fields
Defining marks and channels

Unit 5: Text and Document Visualization   [8 Hrs.]

Text and document data, Levels of text representation, The vector space model, Visualizations of a single text document, Word cloud, Word tree, Text arc, Themescapes and self organiging maps

Unit 6: Evaluating Visualization Techniques and Issues   **[8 Hrs.]**

User and data characteristics, Visualization characteristics, Structures for evaluating visualizations, Visualization bench marking, Issues of data, Issues of cognition, Perception and reasoning, Issues of hardware and software.

Practical Works:

The practical works include the techniques of the data visualization using software tools like MS spread sheet, Python, Matlab, Java, Tableau etc.

References:
1. Fry (2008). *Visualizing Data*. O'Reilly Media.
2. Ware (2012), *Information Visualization: Perception for Design*, Morgan Kaufmann.
3. Telea (2007). *Data Visualization: Principles and Practice*. A. K. Peters, Ltd.

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Code No.: MDS 652

Course Title: **Capstone Project / Thesis**

Nature: Project + Report (Compulsory)   **Credit: 6**

Course Description:

A research project is an important element of Master's Degree Course in Data Science and is written up in the form of a Capstone Project. The project is often seen as the culmination of graduate work, and it is the formal scholarly work. It allows students to reflect and integrate their learning over their earlier semesters of study, and create a descriptive and original work in an area of their interest related to any area of Mathematics, Statistics, Computer Science and Information Technology approved by the Research Committee of SMS TU. While similar in some ways to a thesis, capstone projects may take a wide variety of forms, but most are long-term investigative projects that culminate in a final product, presentation, or performance. For example, students may be asked to select a topic, profession, or problem that interests them, conduct research on the subject, maintain a portfolio of findings or results, create a final product demonstrating their learning acquisition or conclusions and give an oral presentation on the project to a panel of teachers, experts, and practitioners who collectively evaluate its quality.

Learning Objectives:

The aims of the PROJECT are to:
- Put into practice theories and concepts learned on the program;
- Provide an opportunity to study a particular topic in depth through project ;
- Show evidence of independent investigation -data analysis, writing and presentation, and critical analysis;
- Combine relevant theories and suggest alternatives relating the project works ;
- Enable interaction with practitioners (where appropriate to the chosen topic);
- Show evidence of ability to plan and manage a project within deadlines

Learning Outcomes:

After the completion of their a Capstone Project , students should be able to:
- Define, design and deliver an academically rigorous piece of research;
- Understand the relationships between the theoretical concepts taught in class and their application in specific situations;
- Show evidence of a critical and holistic knowledge and have a deeper understanding of their chosen subject area;
- Appreciate practical implications and constraints of the specialist subject;
- Understand the process and decisions to be made in managing a project within strict deadlines.

Capstone Project Activities and Contents

The Capstone Project should focus on a well-formulated research question and show the student's capacity to conduct independent and comprehensive analysis of the subject, taking into account the relevant literature. The following activities and steps will be involved in the project report writing:

- Selecting a relevant topic or issue for the study;
- Getting approval of the Research Committee to pursue the proposed study;
- Locating the relevant literature;
- Locating the sources of data and information;
- Extracting the relevant information from different sources;
- Organizing and analyzing the data;
- Drawing conclusions; and
- Writing a Capstone Project report.

For detail information in writing the Capstone Project Report, see the guidelines

(THE PROJECT REPORT: BASIC GUIDELINES FOR STUDENTS, 2020)

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School of Mathematical Sciences

Master's Degree in Data Science
TRIBHUVAN UNIVERSITY

THE CAPSTONE PROJECT REPORT/THESIS:
BASIC GUIDELINES FOR STUDENTS

Office of the Director
School of Mathematical Sciences
Institute of Science and Technology
Tribhuvan University
Kirtipur

2020

TABLE OF CONTENTS

Section 1
NATURE OF THE CAPSTONE PROJECT

INTRODUCTION
These guidelines are prepared and designed to help Master's Degree in Data Science students of School of the Mathematical Sciences, Tribhuvan University (SMSTU) in the preparation of their Thesis report. The guidelines address only matters of format and presentation, such as arrangement of content, paper, spacing, headings, data analysis, interpretation and referencing. It is the responsibility of each student to ensure that his or her work conforms to the guidelines set put below. The final Capstone Project is approved by the concerned supervisor and the Research Committee of SMSTU with regards to questions of quality and content.

OBJECTIVES OF THE CAPSTONE PROJECT
The Project is an integral part of the postgraduate studies at SMSTU. Towards the end of your study at SMSTU, you are required to undertake a research assignment and prepare an integrative research report in any areas of Mathematics, Statistics, Computer Science, Information Technology and other related Industries as approved by SMSTU.
The Project explores science, engineering, mathematic, technology and business questions as they relate to data available for many enterprises is increasing exponentially. It focuses on findings in related research plus the methodological alternatives. The project thus involves conceptualizing, planning, implementing, and writing up report, which extends knowledge in the subject area under investigation.
This assignment specifically aims to develop knowledge, skills and abilities necessary for conduct of individual research at a level which will make a distinct contribution to knowledge. You are expected to demonstrate the use of appropriate research, methodology, and written skills through the preparation and presentation of a substantial investigation.
Specifically, the objectives of the PROJECT include:
- To provide an opportunity for the students to integrate classroom knowledge and practice.
- To enable graduate students to do an independent study to reflect a creative endeavor that can make a significant contribution to knowledge in a given field.
- To develop students' ability to read professional literature, reports, and other works critically in their design, treatment of data, and conclusions.
- To strengthen the ability of students in presenting their research in building and evaluating mathematical models, exploring them computationally, and analyzing enormous amounts of observed and computed data.

ACTIVITIES INVOLVED IN THE CAPSTONE PROJECT
The following activities will be involved in the Project:
- Selecting a relevant topic or issue for study.
- Locating the relevant literature.
- Locating the sources of data and information.
- Extracting the relevant information from these sources.
- Identifying the various dimensions of the problem or issues.
- Organizing and analyzing the data effectively.
- Drawing inferences and conclusions
- Writing a report.

STUDY REQUIREMENTS

Your PROJECT report shall comply with the following requirements:

- The proposed field of study or topic of project related research must be approved by the concerned supervisor and the Director of SMSTU.
- The work must comply with any requirements advised by the concerned supervisor.
- The work in a PROJECT must reach a satisfactory standard of expression and presentation.
- You must maintain close and regular contact with your supervisor and the Director of SMSTU.

REPORTING REQUIREMENTS

You shall prepare a PROJECT report embodying the results of your research. The report submitted by you shall:

- Be an accurate account of research.
- Relate to the approved research topic.
- Not include work which has been submitted for any other academic award.
- Be written in English.
- Achieve a satisfactory standard of expression and presentation.
- Acknowledge any substantial assistance provided to you during the conduct of research and writing the report
- Conform to the rules and format of SMSTU for the preparation of the CAPSTONE PROJECT report.

LENGTH OF THE PROJECT REPORT

The length of the PROJECT report shall be around 15,000 – 18,000 words (approximately 70-75 pages). This length is exclusive of the materials included in appendices.

MULTIPLE COPIES REQUIRED

i. You shall submit two loose-bound copies of PROJECT report to SMSTU for evaluation. After satisfactory completing all recommended corrections with final *viva-voce*, you shall submit three hard-bound copies and one electronic copy. Each hard bound copy shall be bound black.

ii. The duplicate copies of the original are to be produced using a method which gives a clear and permanent copy (Laser Copy). The use of spirit duplication or carbon copy is not acceptable.

EVALUATION OF THE CAPSTONE PROJECT REPORT

The PROJECT report shall be evaluated by two examiners, one of whom shall be the faculty member of SMSTU. The internal examiner shall be appointed by the Director of SMSTU and the external examiner by the Examination Section, Office of the Dean, Institute of Science and Technology in consultation with Director of SMSTU.

You will be required to attend the *viva-voce* examination and defend your work. You will also be required to give a seminar presentation of your report as organized by SMSTU. The weightage given for viva and the PROJECT report will be 40% (Viva) and 60% (Report) respectively.

Section 2
CAPSTONE PROJECT PROPOSAL

- Having to prepare the proposal for your PROJECT is part of your graduate training. It is an opportunity to organize your thoughts about your research topic, to decide how you will pursue the work, and to spell out what resources (financial, material, and technical) you need to carry out the research. A PROJECT proposal seeks to convince the supervisor(s) or the Graduate Research Committee (GRC) that the research project is feasible.

- The writing of a project proposal is an exercise that you will repeat many times in your professional career. The ability to "sell" a project convincingly is a crucial part of your toolbox of skills.

- A clearly defined research problem (or question) is central to the success of a research project. It helps you to determine that your project is doable before you begin writing the PROJECT report.

- The proposal should explicitly state the problem being addressed or gap in knowledge to be filled, describe the objectives and research techniques to be employed, and include a review of the principal relevant published literature.

- The proposal needs a thread of logic. It should build from a statement of the research problem or gap in knowledge, and follow an outline of detailed objectives that must be achieved (or questions that must be answered) if the problem is to be solved. The presentation of methodology should be clearly connected to stated objectives.

- A PROJECT proposal usually contains some formulations of the following sections:
  - Background of the PROJECT Study
  - Statement of the research problem
  - Research objectives
  - Research questions or hypotheses
  - Rationale for the study
  - Related literature
  - Theoretical/ conceptual framework
  - Methodological design – a plan outlining how and when each step of the project will be done.
  - References

- Maximum length of the proposal should not exceed 2,500 words (excluding references, figures or tables).

- A CAPSTONE PROJECT proposal shall be reviewed by the GRC of SMSTU. The GRC may either (a) accept the proposal as written, or (b) return the proposal for revision.

- Although you are expected to seek guidance from your supervisor in the choice of topic and the method of solving the problem involved, the responsibility for the proposal writing lies with you. You will, as far as possible, work independently and demonstrate the ability to plan outline an acceptable research project.

- Upon approval of the project proposal by the Research Committee, you will be enrolled in the GRC of your department.

<p style="text-align:center">Section 3</p>

PROJECT REPORTING FORMAT

As a student of Master's Degree in Data Science at SMSTU, you are required to write reports for different project assignments in different courses. However, the Project report writing is different from other reports. It is an organized, issues-focused, evidence and data based and creative piece of academic writing. Hence the following structure and guidelines have to be followed while preparing your project report.

STRUCTURE OF THE CAPSTONE PROJECT REPORT

You must carefully read your course information details to ensure that you comply with what instructor stipulates. A PROJECT report is typically made up of three main divisions: (1) preliminary, (2) body, and (3) supplementary. Each of the sections contains different kind of contents.

Preliminary Materials
Title page of the PROJECT
Certification
Deceleration of Authenticity
Table of Contents
List of Tables and Figures
Common Abbreviations Used
Executive Summary

Body of the Report
Chapter I   Introduction
Chapter II   Related Literature and Theoretical Framework
Chapter III   Research Methods
Chapter IV   Analysis and Results
Chapter V   Discussion, Conclusions and Implications

Supplementary Materials
References or Bibliography
Appendices

BODY OF THE PROJECT REPORT

- **Introduction** – Background information on the topic so that you are able to 'place' your research in the context. Details are given of your problem statement, objectives, hypothesis, scope and significance, definition of terms, limitations and an outline of the structure of the PROJECT report

- **Related Literature and Theoretical Framework** – You must carefully structure your findings of the literature survey. It may be useful to do a chronological format where you discuss from the earliest to the latest research, placing your research appropriately in the chronology. Alternately, you could write in a thematic way, outlining the various themes that you discovered in the research regarding the topic. Again, you will need to state where your research fits. Finally, at the end of this chapter, you present your theoretical framework, briefly explaining the measurement of variables.

- **Research Methods –** You have to clearly outline what methodology you used in your research i.e. what you did and how you did it. It must be clearly written so that it would be easy for another researcher to duplicate your research if they wished to. The

contents of this chapter may include research design, population and sample, instrumentation, sources and methods of data collection, and data analysis.

- It is usually written in a 'passive' voice (e.g. the participants were asked to fill in the questionnaire attached in Appendix 1) rather than an 'active' voice (e.g. I asked the participants to fill in the questionnaire attached in Appendix 1).
- Clearly reference any material you have used from other sources. Clearly label and number any diagrams, charts, and graphs. Ensure that they are relevant to the research and add substance to the text rather than just duplicating what you have said. You do not include or discuss the results here.

- **Analysis and Results** – Data are analyzed statistically with mathematical models and results are presented and interpreted. Hypotheses are tested. This is where you indicate what you found in your research. You give the results of your research. Based on these results you give your interpretation. You also discuss the relevance of your results and how your findings fit with other research in the area. It will relate back to your literature review and your introductory project problem statement.

- **Discussion, Conclusions and Implications**

  - **Discussion of the Findings** – This section is the most important section of your project report. Make sure that you allocate enough time and space for a good discussion. This is your opportunity to show that you have understood the significance of your findings and that you are capable of applying theory in an independent manner. The discussion will consist of argumentation. In other words, you investigate a phenomenon from several different perspectives. To discuss means to a question your findings, and to consider different interpretations.

  - **Conclusions and Implications** – This includes key facts from your research findings to help explain your results as needed: you have to summarize, compare and evaluate your research results in context of existing theories, and make comments about its success and effectiveness.

    An implication refers to something which is implied or suggested as naturally being inferred or understood in a certain policy or practice. Your research needs to identify why and how the analyses and interpretations were made and the way key concepts in the analyses evolved. In addition, you need to inform the reader of any unexpected findings or patters that emerged from the data and report a range of evidence to support assertions or interpretations presented.
    You could also indicate some areas where your research has limits and where further research would be useful. Implications of the research for furthering understanding of the research problem need to be explored.

LANGUAGE, TYPING, EDITING AND FORMATTING

KEEP THE LANGUAGE CLEAR AND STRAIGHTFORWARD
- Avoid jargon and acronyms, especially those terms which might be common within your field of work but might be unknown to the general public.
- Use clear and concise writing, and include charts and graphs where appropriate.
- Keep sentences and paragraphs short.
- Delete unnecessary words and phrases.
- Use active verbs as much as possible.

MAINTAIN OBJECTIVITY
- Do not use emotionally charged language when describing your findings, like "very" or "extremely". This can make you sound like a program advocate, thus reducing your objectivity and credibility.
- Use disappointing results to guide recommendations for enhancing services or addressing implementation barriers, rather than dismissing or hiding them.
- Discuss limitations in terms of how information was collected, so that audiences can judge the degree of confidence to place in the results. Every evaluation study has limitations, and it is important to know what they are so stakeholders can consider the findings in context.

TYPING AND EDITING
- The PROJECT report shall be a typescript paper document. It shall not only be submitted in an electronic format.
- The PROJECT report is to be typed on ISO A4 size white bond paper. If diagrams, maps, tables and similar presentations do not fit readily on this sheet size, ISO B4 size may be used. B4 size pages are to be folded and bound so as to open out at the top and the right.
- Typing is to be done on one side of each sheet only, with pages numbered consecutively throughout the report. The following minimal margins are to be observed:

  - Left   3.5cm
  - Top   2.5cm
  - Bottom   2cm
  - Right   2cm
- The PROJECT report must be 1.5-spaced. Single spacing may be used only in the table of contents, footnotes and endnotes, charts, graphs, tables, quotations, appendices, and references.
- Text material should be typed on one side of the paper. The manuscript is to be neat in appearance and without error.
- Typing should be done using the Times New Roman and font size of 12 or equivalent, except for text in the tables.
- SMS TU expects a high standard of editing of the work submitted to it for examination.

FORMATTING
- PROJECT Report writing format should follow the Latest version of APA styles of citation and references.
- Except for text in the tables, all other text must always be justified.

APPENDIX –A
TITLE OF THE CAPSTONE PROJECT/THESIS REPORT

BY
Candidate's Full Name
(Roll. No./Registration no.)

A Project Report Submitted to in partial fulfillment of the requirements
for the degree of
Master's Degree in Data Science

at the
School of Mathematical Sciences
Institute of Science and Technology
Tribhuvan University

Kirtipur
September , 2020

APPENDIX – B

CERTIFICATION

We, the undersigned certify that we have read and hereby recommend for the acceptance by
the School of Mathematical Sciences, Tribhuvan University, a PROJECT /THESIS report
submitted by
…………………………………………………………………………………………………
……………………………………………………… entitled
…………………………………………………………………………………………………
……………………………………………………………………, in a partial fulfillment of the
requirements for the award of Master's Degree in Data Sciences of Tribhuvan University.

_____
PROJECT/Thesis Supervisor
Signature

_____
External Examiner
Signature

_____
GRC chairman
Signature

_____
Director, SMSTU
Date: _____

APPENDIX – C

DECLARATION OF AUTHENTICITY

I, ……………………………………………………………………………….., declare that this PROJECT REPORT /THESIS is my own original work and that it had fully and specifically acknowledged wherever adapted from other sources. I also understand that if at any time it is shown that I have significantly misinterpreted material presented to SMSTU, any credits awarded to me on the basis of that material may be revoked.

Signature: _____
Name:

Date:

Code No.: MDS 653
Course Title: Social Network Analysis   **Full Marks: 75**
Nature: Theory +Practical (Elective)   **Credit: 3**

*Course Description***:**

This course covers different concepts of social network analysis including basics, data collection, descriptive methods, and inferential methods of social network analysis. This course also covers different applications of social network analysis.

*Learning Objectives***:**

After completion of this course, students should be able to
- Understand different concepts, foundations, data collection related to social network analysis
- Know and use different methods in social network analysis
- Identify and study different applications of social network analysis

Course Contents:
Unit 1: Basics of Social Network Analysis   **[8 Hrs.]**

Introduction , Social network and its representation, Types of networks , Network parts and levels of analysis, Network as social structure and institution, Causality in social network studies, History of social network analysis

Unit 2: Data Collection   **[5 Hrs.]**

Boundary specification, Data collection process, Informal bias and issue of reliability, Archival data

Unit 3: Descriptive Methods in Social Network Analysis   **[11 Hrs.]**

Graph and matrix for social network representation, Density , Centrality, centralization, and prestige, Cliques, Multidimensional scaling (MDS) and dendogram, Structural equivalence, Two-mode networks and bipartite matrix

Unit 4: **Inferential Methods in Social Network Analysis**   **[6 Hrs.]**

Permutation and QAP (Quadratic Assignment Procedure) Correlation; P* or Exponential Random Graph Model (ERGM)

Unit 5: Social Network Analysis of Work and Organizations   **[6 Hrs.]**

Personal connections and labour market processes, Intra-organizational networks , Inter-organizational relations

Unit 6: Social Network Analysis in Crime and Terrorism   **[6 Hrs.]**

Personal networks, delinquency, and crime; Neighbourhood networks, Criminal networks

Unit 7: Social Network Analysis in Emotional and Physical Health   **[6 Hrs.]**

Social network Analysis in physical fitness, Social network analysis and Illicit drug use, Social network analysis and Sexually transmitted disease

Laboratory Work:

Students should implement and realize social network analysis using appropriate tools and programming language.

References:
1. Song Yang, Franziska B Keller, Lu Zheng (2016). *Social Network Analysis: Methods and Examples*, Sage Publications (Verlag),
2. Krishna Raj P.M., Ankith Mohan, Srinivasa K.G. (2018). *Practical Social Network Analysis with Python*, Springer.
3. Mehmet Kaya, Jalal Kawash, Suheil Khoury, Min-Yuh Day (2018). *Social Network Based Big Data Analysis and Applications*, Springer International Publishing.
4. Reda Alhajj, Jon Rokne (2018). *Encyclopedia of Social Network Analysis and Mining*, Springer New York.
5. Xiaoming Fu, Jar-Der Luo, Margarete Boos (2017). *Social Network Analysis: Interdisciplinary Approaches and Case Studies*, CRC Press.

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Code No.: MDS 654
Course Title: Actuarial Data Analysis   **Full Marks: 75**
Nature: Theory +Practical (Elective)   **Credit: 3**

*Course Description***:**

In this course students will learn the fundamental concept of Actuarial Data Analysis and they will able to apply necessary tools and techniques to model the actuarial data by using R. The goal of the course is to prepare the student to examine quality of provided data and fitting appropriate predictive model such as generalized linear models, decision trees, Survival Analysis in insurance. Moreover, in this course students will get idea how insurance company apply predictive modeling techniques to solve the business problems.

*Learning Objectives***:**

After completion of the course, students will be able to
- Explore graphically and summaries time series data using R.
- Understand the different types of predictive modeling problems.
- Create a variety of graphs using the ggplot2 package.
- Select and validate a GLM appropriately, classification problem.
- Select appropriate hyperparameters for regularized regression.
- Construct regression and classification trees.
- Select appropriate hyperparameters for decision trees and related techniques.
- Do survival analysis in insurance
- Simulate of modeles

*Course Contents***:**

Unit 1: Data Visualization   **[5 Hrs.]**

Write effective graphs in RStudio, key principles of constructing graphs, create effective graphs in RStudio, graphs using the ggplot2 package.

Unit 2: Data Types and Exploration   **[6 Hrs.]**

Work with various data types, principles of data design, construct a variety of common visualizations for exploring data, structured, unstructured, and semi-structured data. Methods of handling missing data, univariate and bivariate data exploration techniques, effective data design with respect to time frame, sampling, and granularity.

Unit 3: Data Issues and Resolutions   **[7 Hrs.]**

Evaluate data quality, Resolve data issues, Identify regulatory, Ethical issues, Data sources, Outliers and other data issues, Non-linear relationships via transformations, Regulations, standards, and ethics surrounding predictive modeling and data collection.

Unit 4: Generalized Linear Models   **[10 Hrs.]**

Implement ordinary least squares regression in R and understand model assumptions, GLM model assumptions, interpret model coefficients, interaction terms, offsets, and

weights, validate a GLM, bias, variance, model complexity, the bias-variance trade-off, hyperparameters for regularized regression.

Unit 5: Decision Trees   [10 Hrs.]

The basics of decision trees, motivation behind decision trees, regression trees, classification trees, trees versus linear models, bagging & random forests to improve accuracy, boosting to improve accuracy, fitting classification trees, fitting regression trees, selecting appropriate hyperparameters for decision trees and related techniques.

Unit 6: Survival Analysis in Insurance   [10 Hrs.]

Kaplan-Meier and Nelson-Aalen estimator, Log-rank test, Parametric regression models, Cox regression models, Simulation: Model comparison, Accelerated failure Time models.

Practical Works:

The practical works consist of lab work using R/RStudio software. Project work on predictive modeling techniques to solve (business) problems must be highlighted.

References:

1. Edward W. Frees (2010). *Regression Modeling with Actuarial and Financial Applications*. New York:Cambridge.
2. James, Witten, Hastie, Tibshirani (2013). *An Introduction to Statistical Learning, with Applications in R*. New York: Springer.
3. Healy E. (2019). *Data Visualization: A Practical Introduction*. Princeton University Press.
4. Lander (2017). *R for Everyone: Advanced Analytics and Graphics*, 2nd ed. Boston: Addison-Wesley.
5. Ambrose L. (2019). *ACTEX Study Manual for SOA Exam Predictive Analytics*. USA.
6. D. C. M. Dickson, M. R. Hardy and H. R. Waters (2009) *Actuarial Mathematics for Life contingtent Risks*, Cambridge University Press, New York.

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Code No.: MDS 655
Course Title: Deep Learning   **Full Marks: 75**
Nature: Theory + Practical (Elective)   **Credit: 3**

*Course Description***:**

The course is designed to provide the students of Graduate level with the fundamental concepts of Deep Learning. The course is divided into two parts: first one is the basic foundation with the introduction to Machine Learning basics, The neural network, Training feed-forward neural networks and beyond gradient descent; and the second one deals with convolutional neural networks and models for sequence analysis.

*Learning Objectives***:**

The major objective of the course is to prepare the students to design Deep Learning models/solutions to solve the real-world problems. Students will familiarize with the Deep Learning libraries and tools like Keras, Tensor Flow, and Pytorch thus learning to understand the different theoretical and implementation aspects of Deep Learning models.

*Course Contents***:**

Unit 1: Machine Learning Basics   [4 Hrs.]

Learning algorithms, Capacity, overfitting and underfitting, Hyper parameters and validation sets, Estimators, bias and variance , Maximum likelihood estimation, Bayesian statistics,   Supervised learning algorithms, Unsupervised learning, Algorithms, Stochastic gradient descent, Building a machine learning algorithm

Unit 2: The Neural Network   [4 Hrs.]

Building intelligent machines, The limits of traditional computer programs, The mechanics of machine learning, The neuron, Expressing linear perceptrons as neurons; Feed-forward neural networks, Linear neurons and their limitations, Sigmoid, Tanh, and ReLU neurons, Softmax output layers.

Unit 3: Training Feed-Forward Neural Networks   [4 Hrs.]

The Fast-Food problem, Gradient descent, The delta rule and learning rates, Gradient descent with sigmoidal neurons, The Back propagation algorithm, Stochastic and mini batch gradient descent, Test sets, validation sets, and over fitting; Preventing over fitting in deep neural networks

Unit 4: Beyond Gradient Descent   [8 Hrs.]

The challenges with gradient descent, Local minima in the error surfaces of deep networks , Model identifiability ,Pesky in deep networks, Flat regions in the error surface, Gradient points, Momentum-based optimizations, A brief view of second-order methods, Learning rate adaptation,   AdaGrad – Accumulating historical gradients,   RMSProp – Exponentially weighted moving average of gradients,
  Adam – Combining momentum and RMSProp

Unit 5: Convolutional Neural Networks   **[8 Hrs.]**

Neurons in human vision, The shortcomings of feature selection, Vanilla deep neural networks don't scale, Filters and feature maps, Full description of the convolution layer , Max pooling, Full architectural description of convolution networks, Closing the loop on MNIST with convolutional networks, Image preprocessing pipelines Enable more Robust models, Accelerating training with batch normalization, Building a convolutional network for CIFAR-10,
Visualizing learning in convolutional, Networks, Leveraging convolutional filters to replicate artistic styles, Learning convolutional filters for other problem domains

Unit 6: Embedding and Representation Learning   **[10 Hrs.]**

Learning lower-dimensional representations, Principal component analysis,
Motivating the autoencoder architecture, Implementing an autoencoder in tensor flow , Denoising to Force Robust Representations; Sparsity in Autoencoders
 Context and input vector, The Word2Vec framework, Implementing the Skip-Gram architecture

Unit 7: Models for Sequence Analysis   **[10 Hrs.]**

Analyzing variable-length inputs,Tackling seq2seq with neural N-Grams,
Implementing a part-of-speech tagger, Dependency parsing and syntax net,
Beam search and global normalization, A case for stateful deep learning models,
Recurrent neural networks, The challenges with vanishing gradients,
Long Short-Term Memory (LSTM) units, Tensor flow primitives for RNN models,
Implementing a sentiment analysis model, Solving Seq2Seq tasks with recurrent neural networks, Augmenting recurrent networks with attention, Dissecting a neural translation network.

Laboratory Works:

The lab works will introduce the students with the Deep Learning architecture and framework along with the different learning algorithms. Lab work would give students a hands-on knowledge on the different libraries, modules and frameworks of Deep Learning.

References:
1. Ian Goodfellow, Yoshua Bengio, Aaron Courville (2016). *Deep Learning*, MIT Press.
2. Nikhil Buduma and Nicholas Lacascio (2017). *Fundamentals of Deep Learning – Designing Next-Generation Machine Intelligence Algorithms*, O'Reilly.
3. Sudarsan Ravichaniran (2019). *Hands-On Deep Learning Algorithms with Python*, Packt Publishing.
4. Francois Chollet(2018). *Deep Learning with Python*. Manning Publications.
5. Josh Patterson & Adam Gibson(2017). *Deep Learning – A Practitioner's Approach*, O'Reilly.
6. Michael Nielson. *Neural Networks and Deep Learning*. [http://neuralnetworksanddeeplearning.com]
7. Nikhil Ketkar (2017). *Deep Learning with Python – A Hands-on Introduction*, APress.

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Code No. : MDS 656
Course Title: Business Analytics   **Full Marks: 75**
Nature: Theory + Practical (Elective)   **Credit: 3**

*Course Description***:**

This course provides an overview of business analytics from both models and strategy perspectives. It mainly focuses multi-criteria decision making, performance analytics and people analytics. The course comprises particularly the widely used tools in business analytics: AHP and DEA.

Learning Objectives:

After the completion of the course, students will be able to
- Identify the existing business analytics models in real world
- Link between the strategy at functional level and business analytics
- Solve the complex multi-criteria decision problems
- Use optimization tools and techniques in performance analysis
- Link people analytics with overall organizations' mission

Course Contents:

Unit 1: **Introduction to Business Analytics**   **[4 Hrs.]**
Meaning of business analytics, Evolution of business analytics, Scope of business analytics, Data for business analytics, Models in business analytics, Problem solving with analytics

Unit 2: Business Analytics at Strategy level   **[8 Hrs.]**
Link between strategy and the deployment of business analytics, Strategy and business analytics: No formal link between strategy and business analytics, Business analytics supports strategy at a functional level, Dialogue between the strategy and business analytics functions, Information as a strategic resource ; Information prioritization: The product and innovation perspective, Customer relations perspectives , Analyst's role in the business analytic model

Unit 3: Multi-criteria Decision Making   **[12 Hrs.]**
Analytic hierarchy process (AHP), Establishing priorities using AHP: Pairwise comparisons, Pair wise comparison matrix, synthesization, consistency; Overall priority ranking, Application of AHP in various areas

Unit 4: Performance Analytics   **[12 Hrs.]**
Basic concept of efficiency measurement, Frontier analysis**,** Mathematical programming aspects of data envelopment analysis (DEA) ; output maximization and Input minimization DEA programs, Charnes, Cooper and Rhodes (CCR) model, Banker, Charnes and Cooper (BCC) model.

Unit 5: People Analytics [12 Hrs.]

Introduction, Linking people analytics with overall business plan, Workforce planning analytics, Employee engagement surveys, Big data and people analytics , HR information system

Practical Works:

Use of Microsoft Excel and related software to solve the problem

Research project to carry on the on-hand experience in real world phenomena

References:

1. Anderson D.R. Sweeney D.J., Williams T.A. & Martin K. (2011). *An introduction to Management Science Quantitative Approaches to Decision Making*. Delhi: Cengage Learning India Private Limited.
2. Gert H.N. Laursen & Jesper Thorlund. (2017). *Business Analytics for Managers*. New Jersey: John Wiley & Sons Inc. Retrieved from https://b-ok.asia/book/2871501/a24d0a
3. James R. Evan . (2017). *Business Analytics Methods, Models and Decisions*. England: Pearson Education Limited
4. Jean Paul Isson & Jesse S. Harriott .(2016). *People Analytics in the Era of Big Data* . New Jersey: John Wiley & Sons Inc. Retrieved from https://b-ok.asia/book/2765101/ccbe6e
5. Ramanathan R. (2003). *An Introduction to Data Envelopment Analysis A Tool for Performance Measurement*. New Delhi: Sage Publications India Pvt. Ltd.

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Code No.: MDS 657
Course Title: Bioinformatics   **Full Marks: 75**
Nature: Theory +Practical (Elective)   **Credit: 3**

*Course Description***:**
   This course is an application of computational methods used in biological data for data analysis and discovery. It provides basic concepts on molecular biology, explores important biological databases and analysis of those data using various algorithms and available tools. It also encourages students to research advanced computer technology in order to solve complex biological problems.

*Learning Objectives***:**
Upon completion of the course students must be able to:
   - Understand basic concepts of molecular biology and biological data.
   - Know different biological databases and tools to retrieve and analyze the relevant data.
   - Perform pairwise and multiple sequence alignments and construct phylogenetic trees.
   - Predict structure and function of protein.
   - Use computational tools for genomic data.
   - Gain knowledge in drug discovery and emerging fields in bioinformatics.

Course Contents:

Unit 1: Introduction   [8 Hrs.]
   Overview, history, scope and application areas in bioinformatics, Major databases in bioinformatics, File formats, Molecular biology, Central dogma of molecular biology, Information search and data retrieval tools (Entrez, SRS), Data mining of biological data, Genome analysis, Genome mappings, Genome sequencing, Sequence assembly and annotation tools, Human Genome project.

Unit 2: Pairwise and Multiple Sequence Alignment   [10 Hrs.]
   Pairwise sequence alignment, Substitution matrices PAM & BLOSUM, Dot matrix method, Dynamic programming:- Local Alignment and Global Alignment, Heuristic Method:- FASTA, BLAST, comparisons, Multiple sequence alignment, Guide tree, Types of MSA, Applications.

Unit 3: Phylogenetic Analysis   [7 Hrs.]
   Introduction, Distances matrix, Types of trees, Tree construction methods.
   Distance based method (UPGMA, Fitch Margolis method, Neighbor-Joining), Character base method (Parsimony and maximum likelihood method), Application of phylogenetic analysis.

Unit 4: Gene Prediction, Expression and Microarrays.   [6 Hrs.]
   Basics of gene prediction, Pattern recognition- gene prediction methods, Tools- gene expression, Working with DNA microarrays, Clustering gene expression profiles- data sources and tools for microarray analysis, Applications.

Unit 5: Protein Classification and Structure Prediction.   [10 Hrs.]

 Overview of protein structure, Protein structure visualization - structure based protein classification, Protein structure databases, Tools - protein structure alignment, Domain architecture databases, Tools - Protein classification approaches - Protein identification and characterization - Primary structure analysis and Prediction- Secondary structure analysis and Prediction - Motifs, profiles, patterns, fingerprints search - Methods of sequence based protein prediction, 2D and 3D structure prediction, Protein function prediction.

Unit 6: Drug Discovery and Current Advancement in Bioinformatics.   [7 Hrs.]

Areas influencing drug discovery, Pharmacogenetics, Applications , Parameters in drug discovery - drug discovery technologies, Target discovery strategy, Precision medicine, Machine learning, Artificial informatics,Chemoinformatics, Immuno informatics.

Practical Works:

The practical work includes the important aspects of biological databases and their queries. Sequence analysis and alignment using Basic Alignment Search Tool (BLAST). Tools used for multiple sequence alignment and phylogenetic analysis, gene prediction, secondary structure and tertiary structure predictions are also included.

References:

1. Attwood T.K. and Parry-Smith.(1999). *Introduction to Bioinformatics*, Addison Wesley Longman.
2. David W Mount, Bioinformatics.(2004). *Sequence and Genome Analysis*, 2nd edition, CBS publishers.
3. Arun Jagota(2001).*Data Analysis and Classification for Bioinformatics*, Pine Press.
4. Des Higgins and Willie Taylor.(2000). *Bioinformatics Sequence, Structures and Databanks*, Oxford University Press, USA.
5. Durbin R., Eddy S., Krogh A.& Mitchison G.(1999). *Biological Sequence Analysis*
6. Dov Stekel(2003*). Microarray bioinformatics*, Cambridge.
7. Des Higgins, Willie Taylor.(2010). *Bioinformatics Sequence Structure & Data Banks. A practical approach*.

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Code No.: MDS 658
Paper: Economic Analysis   **Full Marks: 75**
Nature: Theory +Practical (Elective)   **Credit: 3**

*Course Description***:**

In this course students will learn the methods and tools of economic analysis for giving advanced knowledge of economic theory and suggesting ways to apply the knowledge in formulating and analyzing economic models and theories.

*Learning Objectives***:**

The objective of this course is to provide advanced knowledge on micro and macroeconomic analysis. Upon the completion of this course, students will be able to understand analytical tools and apply them in formulating and analyzing economic models and theories.

Course Contents:

Unit 1 : Theory of Consumer Behaviour   [6 Hrs.]

Total and marginal utility, Consumer equilibrium, Indifference curves, The marginal rate of substitution, Characteristics of indifference curves, The budget constraint line, Consumer equilibrium, The price-consumption curve and the consumer's demand curve, Separation of the substitution and income effects, Theory of revealed preference, Consumer surplus and elasticity of demand, The problem of choice in situations involving risk and uncertainty (attitude towards risk and insurance).

Unit 2: Theory of Production and Costs   [9 Hrs.]

Production with one variable input: Total, average, and marginal product. The shapes of the average and marginal product curves, Stages of production,
Production with two variable inputs: Isoquants, Short-Run total cost curves, The long-run average cost curve, The long-run marginal cost curve, The long-run total cost curve, The Cobb-Douglas production function.

Unit 3: Price-Output under Perfect Competition and Monopoly   [9 Hrs.]

Perfect competition: Short-run and long-run equilibrium, Supply curves of the firm and industry, Dynamic changes and industry equilibrium.
Monopoly: Short-run and Long-run equilibrium, Predictions in dynamic changes, Regulated monopoly (Taxation, and price regulation), Govt. regulated monopoly, Discriminating monopoly. Comparison competitive and monopoly firms and excess capacity.

Unit 4: Price- Output under Monopolistic Competition and Oligopoly: Monopolistic Competitive Market: [9 Hrs.]

Product differentiation and demand curve, Industry and Group, Chamberlin's model: with entry and price competitions and equilibrium of firms, Comparison competitive and monopolistic competitive markets, Concept of excess capacity; Non-collusive oligopoly: Cournout's model, Bertrand's model, Chamberlin's model, Stackelberg's model and Kinked demand model of oligopoly.

Unit 5: Classical Theory of Output and Employment [6 Hrs.]

The Classical postulates; Say's law of market, Full employment – Demand for and Supply of labour; Labour supply and money wages; Unemployment and wage rigidity; Overall equilibrium in the basic static model (Goods, labour & money markets).

Unit 6: GDP, Growth, and Instability: Measuring Domestic Output and National Income [9 Hrs.]

Gross domestic product: A monetary measure / Avoiding multiple counting / GDP Excludes nonproduction transactions / Two ways of looking at GDP: Spending and Income, The expenditures approach: Personal consumption expenditures (*C*)/Gross private domestic investment (*I g*)/Government purchases (*G*)/Net exports (*X n*)/ Putting it all together: GDP $C \_ Ig \_ G \_ X n$, The income approach: Compensation of employees/ Rents/ Interest *l* Proprietors' Income/ Corporate Profits/ Taxes on production and imports/ From national income to GDP, Other national accounts: Net domestic product/National income/ Personal income/ Disposable income / The circular flow revisited, Nominal GDP versus Real GDP: Adjustment process in a one-product economy/An alternative method / Real-world considerations and data.

Practical Works:

The practical work includes: The theory will be empirical test with the deductive logical approach (microeconomics and macroeconomics theory to real world).

References:
1. Dominick Salvatore (2006). *Managerial Economics in a Global Economy* (4th ed.). Thomson Publication.
2. Mark Hirschey and James L. Pappas (1992) *Fundamentals of Managerial Economics*- 4th ed. A Harcourt Brace Javanovich College Publication.
3. Campbell R. McConnell; & Stanley L. Brue Sean M. Flynn (2009). *Economics: Principles, Problems, and Policies* -18th ed. McGraw-Hill/Irwin Publication.
4. Paula A. Samuelson; & William d. Nordhaus, (2010). *Principles of Economics*-19th ed. McGraw-Hill/Irwin Publication.
5. N. Gregory Mankiw (2013). *Principles of Economics* -17th ed. Cengage Learning Publication.

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