Course Title: Time series analysis using statistical and machine learning tools

Course Description:
This course provides an introduction to the analysis and forecasting of time series data. Time series data is prevalent in various fields, including finance, economics, engineering, and social sciences. The course covers fundamental concepts, modeling techniques, and prediction methods for time series analysis, both from classical and machine learning perspectives. Topics include understanding time series data, stationarity, modeling with SARIMA (Seasonal Autoregressive Integrated Moving Average) models, frequency domain analysis, Kalman filters, handling longitudinal data, and prediction using classical and machine learning tools.

Course Syllabus:

Module 1: Introduction to Time Series Analysis

What is a time series?
Types and characteristics of time series data
Time series components: trend, seasonality, and noise
Basic exploratory data analysis for time series

Module 2: Modeling Time Series with SARIMA Models

Autoregressive (AR) models
Moving Average (MA) models
Autoregressive Moving Average (ARMA) models
Seasonal ARIMA (SARIMA) models
Model identification, estimation, and diagnostic checking

Module 3: Frequency Domain Analysis

Fourier analysis and Fourier transform
Periodogram and spectral analysis
Power spectral density estimation
Filtering in the frequency domain

Module 4: Kalman Filters for Time Series Analysis

Introduction to Kalman filters
State-space models and the Kalman filter equations
Filtering and smoothing with the Kalman filter
Applications in time series analysis and forecasting

Module 4: Longitudinal Data Analysis

Understanding longitudinal data
Handling panel data and repeated measures
Mixed-effects models for longitudinal data
Longitudinal forecasting techniques

Module 7: Prediction using Classical Methods

Exponential smoothing models (Simple, Holt's, and Winter's methods)
Autoregressive Integrated Moving Average (ARIMA) models
Forecast evaluation and accuracy measures
Model selection and model diagnostics

Module 8: Prediction using Machine Learning Tools

Introduction to machine learning for time series analysis
Regression-based methods (linear regression, support vector regression, etc.)
Neural networks for time series forecasting (e.g., LSTM, GRU)
Evaluation and comparison of machine learning models

Course Project:
Students will complete a time series analysis and forecasting project using real-world data. The project will involve data preprocessing, model selection, estimation, and evaluation of forecast accuracy.

Prerequisites:

Basic knowledge of statistics and probability
Familiarity with regression analysis and hypothesis testing
Proficiency in a programming language (e.g., Python, R) for data analysis

Assessment:

Assignments throughout the course: 20% of the final grade.
Course project: 80% of the final grade

Note: The syllabus is subject to modification and can be tailored according to the specific needs and time constraints of the course.