NATIONAL UNIVERSITY OF SAN MARCOS

FACULTY OF MATHEMATICAL SCIENCES

SYLLABUS

1. GENERAL INFORMATION

1.1 Course name	:	Time series analysis
1.2 Code	:	CS273
1.3 Academic Program	:	Scientific Computing
1.4 Credits	:	4
1.5 Prerrequisites	:	MA351. Statistics and Probabilities. (6^{th} Sem)
1.6 Type of Course	:	Elective
1.7 Area of Studies	:	Estudios Generales
1.8 Number of Weeks	:	16
1.9 Hours per week	:	2 HT; 4 HP;
1.10 Cycle	:	I
1.11 Learning modality	:	Face to face
1.12 Academic Period	:	2026-I
1.13 Semester Start Date	:	
1.14 Semester End Date	:	

2. PROFESSORS

Meetings after coordination with the professor

3. INTRODUCTION TO THE COURSE

In various fields such as finance, meteorology, and engineering, data is collected sequentially over time, presenting unique temporal dependencies. This course introduces the theoretical and practical foundations for analyzing, modeling, and forecasting time series. It covers everything from classical decomposition methods to advanced stochastic models (ARIMA, GARCH), allowing the student to extract relevant information from dynamic processes and make decisions based on rigorous predictions.

4. GOALS

- Understand the fundamental components of a time series (trend, seasonality, cycle, and residual).
- Identify and transform series to achieve stationarity.
- Model stochastic processes using Box-Jenkins methodologies.
- Evaluate forecast quality through error metrics and temporal cross-validation.
- Implement advanced predictive models for series with volatility or complex dependencies.

5. COMPETENCES

ABET-3) An ability to develop and conduct experiments or test hypotheses, analyze and interpret data, and use scientific judgment to draw conclusions. (Usage)

ABET-2) An ability to formulate or design a system, process, procedure, or program for the intended purpose. (Usage)

6. TOPICS

Unit 1: Introduction and Fundamental Concepts (8 hours)	
Competences Expected: ABET-2,ABET-3	
Topics	**Learning Outcomes**
• Definition and examples of time series. • Series components: Trend, Seasonality, and Noise. • Lag and difference operators. • Smoothing operations: Simple and weighted moving averages.	• Decompose a time series into its basic components [Usar]. • Identify visual patterns of temporal dependence in real data [Familiarizarse].
Readings : [**Hyndman2021**], [**Box2015**]	

Unit 2: Stationarity and Autocorrelation Functions (8 hours)	
Competences Expected: ABET-2,ABET-3	
Topics	**Learning Outcomes**
• Weak and strong stationarity. • Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF). • White noise and Random Walk. • Unit root tests (Augmented Dickey-Fuller).	• Determine if a series is stationary using statistical tests [Usar]. • Interpret correlograms to identify possible stochastic models [Evaluar].
Readings : [**Shumway2017**], [**Box2015**]	

Unit 3: Linear Process Models (AR and MA) (8 hours)	
Competences Expected: ABET-2,ABET-3	
Topics	**Learning Outcomes**
• Autoregressive processes (AR). • Moving Average processes (MA). • Invertibility and stability conditions. • Parameter estimation and information criteria (AIC, BIC).	• Model linear dependencies in stationary time series [Usar]. • Select the optimal model order based on statistical criteria [Evaluar].
Readings : [**Shumway2017**], [**Brockwell2016**]	

Unit 4: Box-Jenkins Methodology and ARIMA Models (8 hours)	
Competences Expected: ABET-2,ABET-3	
Topics	**Learning Outcomes**
• Integrated models (ARIMA). • Identification, estimation, and diagnostic checking. • Residual analysis and Ljung-Box test. • Seasonal models (SARIMA).	• Implement the full Box-Jenkins modeling cycle [Usar]. • Validate model adequacy through residual analysis [Evaluar].
Readings : [**Box2015**], [**Hyndman2021**]	

Unit 5: Forecasting and Model Evaluation (8 hours)	
Competences Expected: ABET-2,ABET-3	
Topics	**Learning Outcomes**
• Point forecasts and confidence intervals. • Error metrics: MAE, RMSE, MAPE, and MASE. • Time Series Cross-Validation (Time Series Split). • Forecast combinations.	• Generate future predictions with their respective uncertainty margins [Usar]. • Rigorously compare the performance of multiple predictive models [Evaluar].
Readings : [**Hyndman2021**], [**Brockwell2016**]	

Unit 6: Volatility Models (ARCH and GARCH) (8 hours)	
Competences Expected: ABET-2,ABET-3	
Topics	**Learning Outcomes**
• Conditional heteroskedasticity in financial series. • ARCH (Autoregressive Conditional Heteroskedasticity) models. • GARCH models and their extensions. • Risk estimation and Value at Risk (VaR).	• Identify the presence of volatility clustering in financial data [Usar]. • Model conditional variance of complex dynamic processes [Evaluar].
Readings : [**Tsay2010**], [**Shumway2017**]	

Unit 7: Ethics and Responsibility in Forecasting (8 hours)	
Competences Expected: ABET-2,ABET-3	
Topics	**Learning Outcomes**
• Socioeconomic consequences of erroneous forecasts. • Transparency in communicating uncertainty. • Ethical use of sensitive temporal data and privacy. • Biases in automated prediction algorithms.	• Recognize the ethical impact of decisions based on predictions [Familiarizarse]. • Communicate model limitations and risks to stakeholders [Usar].
Readings : [**Hyndman2021**]	

Unit 8: Implementation and Real-World Applications (8 hours)	
Competences Expected: ABET-2,ABET-3	
Topics	**Learning Outcomes**
• Computational tools (R: ‘forecast‘, ‘fable‘; Python: ‘statsmodels‘). • Automation of forecasting workflows. • Applications in energy demand, inventory, and markets. • Presentation of a final prediction project.	• Develop automated forecasting systems using specialized software [Evaluar]. • Solve a real prediction problem by integrating all course stages [Evaluar].
Readings : [**Tsay2010**], [**Hyndman2021**]	

7. WORKPLAN

7.1 Methodology

Individual and team participation is encouraged to present their ideas, motivating them with additional points in the different stages of the course evaluation.

7.2 Theory Sessions

The theory sessions are held in master classes with activities including active learning and roleplay to allow students to internalize the concepts.

7.3 Practical Sessions

The practical sessions are held in class where a series of exercises and/or practical concepts are developed through problem solving, problem solving, specific exercises and/or in application contexts.

8. EVALUATION SYSTEM

********* EVALUATION MISSING ********

9. BASIC BIBLIOGRAPHY