Course Name:	THE ANALYSIS OF TIME SERIES
Course Code:	STAT6631
# of Contact Hrs:	One Semester (13 weeks - 36 hours of lectures and 24 hours of supervised laboratory time)
Credits:	4
Level:	Graduate
Pre-requisite:	None

RATIONALE

Classical statistical analysis is ineffective when applied to sets of observations that are correlated in time: for example share prices. Time series analysis is a specialised branch of statistical science which deals with such data sets, providing an essential toolset for statisticians, scientists, engineers and financial analysts.

AIM

The course covers the fundamental concepts required for the description, modeling and forecasting of time series data, both in the time- and frequency-domains. Attention to the theoretical underpinnings of the subject is complemented by the analysis of real-world data sets, and a practical laboratory component introduces students to the software package R.

LEARNING OUTCOMES

On completion of this course, the student should be able to:

- Classify time series and identify forms of variation present in data;
- Generate time plots and correlograms of time series data using software;
- Prove the main properties of random walk, MA, AR, ARMA, (S)ARIMA, ARCH and GARCH models
- Fit time series models to real-world data sets;
- Interpret and evaluate time series models fitted by computer packages;
- Produce forecasts (with associated error bounds) from a real-world data set using a Holt-Winters or Box-Jenkins approach;

- Explain the significance of the Nyquist and fundamental Fourier frequencies;
- Prove Parseval's Theorem;
- Derive the spectral representation of selected stochastic processes.

TEACHING METHODS:

Students will be exposed to the theoretical aspects of Time Series Analysis via lectures. The practical application of methods encountered to real-world data sets will take place in parallel computer laboratory sessions where they will implement and explore the ideas and techniques encountered in the course.

The total estimated 48 contact hours may be accounted for as follows: 36 hours of lectures and 24 hours of supervised laboratory time (counted overall as 12 contact hours). In the computer laboratory sessions they will learn to handle large data sets, parallel computing and to implement theoretical/numerical schemes learnt in the lecture hours. Course material, including laboratory data sets and sample code, will be posted on the webpage http://ourvle.mona.uwi.edu/

SYLLABUS

Introduction [3 hours]: Examples of time series and classification; objectives of time series analysis; types of variation; stationary time series; the time plot; transformations; filtering; differencing; basic models and decomposition of time series; the correlogram.

Stochastic models for time series [7 hours]: Stochastic processes (ensemble and realisation); stationary processes; autocovariance and autocorrelation functions; purely random processes; random walks; moving average processes; invertibility; autoregressive processes; mixed ARMA models; integrated ARIMA models; ARCH and GARCH models.

Estimation in the time domain [6 hours]: Estimating the mean, autocovariance and autocorrelation functions; interpreting the correlogram; fitting autoregressive and moving average process; estimating the parameters of an ARMA model; estimating the parameters of an ARIMA model; the Box-Jenkins Seasonal (SARIMA) model; residual analysis and the Akaike Information Criterion.

Forecasting [6 hours]: Automatic and non-automatic forecasting; Exponential smoothing; the Holt-Winters method; Box-Jenkins forecasting.

Stationary processes in the frequency domain [7 hours] The spectral distribution function; the spectral density function, the spectrum of a continuous process, derivation of selected spectra.

Spectral Analysis [7 hours] Fourier analysis; a simple sinusoidal model, the fundamental Fourier and Nyquist frequencies; the periodogram; spectral analysis: consistent estimation procedures; confidence intervals for the spectrum, a comparison of different estimation procedures (spectral window or kernal, bandwidth.

Laboratory work [24 hours]: Time series basics – time plots, decomposing data, multiple time series, differencing; Autocorrelation and the correlogram; Holt-Winters forecasting; Fitting models to data and model-based forecasting; Spectral analysis of time series.

Total contact hrs = 48 hrs i.e. 36 hrs lecture + 24 hrs lab

ASSESSMENT:

The course assessment has two components consisting of coursework (40%) and final exam (60%)

One in-course test – 20% of overall grade;

Laboratory assignment – 20% of overall grade;

Final exam (3 hours) – 60% of overall grade.

REFERENCE MATERIAL

Books:

Cowpertwait, P. S.P. & A. V. Metcalfe (2009). *Introductory Time Series with R*, Springer. ISBN-10: 0387886974

Chatfield, C (2004). *The Analysis of Time Series, an Introduction (Sixth Edition)*, Chapman & Hall/CRC. ISBN 0203491688

ONLINE RESOURCES:

www.r-project.org: R project homepage – software downloads, tutorials and documentation;

http://staff.elena.aut.ac.nz/Paul-Cowpertwait/ts/: Supplemental material, including data sets, for the book by Cowpertwait & Metcalfe.