MIOT H6014: Statistical Analysis for Engineers

Short Title:	Statistical Analysis for Engineers APPROVED
Full Title:	Statistical Analysis for Engineers

Module Code:	MIOT H6014

ECTS credits:	5

NFQ Level:	9

Module Delivered in	2 programme(s)

Module Contributor:	Damian Cox

Module Description:	The purpose of this module is to provide the learner with the statistical concepts and tools necessary for research in a field of engineering. The module will underpin specific engineering topics such as statistical process control, quality control and reliability analysis. To do this, the learner will cover the fundamental ideas of probability and descriptive statistics, moving on to Hypothesis testing and the design of experiments. This learning is complemented by an introduction via practical classes to several statistical software packages programs. Students are provided with the skills both to plan and carry out research and the ability to both read and critique the research of others in engineering.

Learning Outcomes:

On successful completion of this module the learner will be able to

1. Apply the laws of probability to questions involving random variables and events, and move on to the concept of a random variable and its distribution, the meaning of expected values, and the properties of common distributions such as the normal, binomial, Poisson and exponential distributions.
2. Apply knowledge of random variables and their distributions, including the central limit theorem, to concepts in quality control.
3. Interpret the concept of a statistic as a random variable arising from sample data, with the central limit theorem determining the behaviour of such statistics and thereby underpinning many statistical tests, and so apply a range of statistical tests.
4. Design or explain the chosen structure of an experiment and the meaning of appropriate data analysis produced for that experiment, based on the students understanding of the properties of Analysis of Variance and other statistical tests.
5. Write reports of trials and experiments carried out to the standard and structure required for publication and evaluate statistical analysis presented in research papers.
6. Apply a range of typical statistical packages to the analysis of data produced in trials and experiments.

Module Content & Assessment

Indicative Content
Descriptive Statistics Measures of central tendency and dispersal. Linear regression and correlation as data analysis techniques.
Fundamentals of Probability The definition of the fundamental ideas of events, experiments and the frequentist definition of probability. Independent events, conditional probabilities and the addition and multiplication laws. Bayes Theorem.
Random Variables and Distributions The concepts of a random variable and its distribution, expected values, the definition of population parameters in terms of the probability distribution function and the cumulative probability distribution. Discrete and continuous probability distributions, including the exponential, normal, binomial and Poisson distributions. Kurtosis. The moments of a distribution.
Fundamentals of Hypothesis Testing The concept of a Hypothesis test. The concept of a statistic. The common population parameters as statistics. The Central Limit Theorem and the concept of standard error. The role of the normal distribution arising from the Central Limit theorem. The representation of the results of a test; critical values and confidence intervals. The concept and limitations of a Hypothesis test, including type I and II errors and their probabilities.
Standard Hypothesis Tests Distributions including the 'Student t', the chi-square and the F distributions. The F distribution as a ratio of chi-square distributions. Standard tests, including tests on means and variances, paired sample and unpaired tests on comparisons of means. Categorical tests using the chi-square distribution, such as goodness-of-fit tests to a distribution and tests for independence. Linear regression and correlation as statistical tests. The power of a statistical test. Effects sizes and the calculation of sample sizes.
Advanced Statistics The design of experiments and the comparison of group means by one- and two-way analysis of variance (ANOVA). Relating an experiment to the form of the data collected. The type and nature of response variables and the concept of an attribute. Multiple regression and the General Linear Model. Easing of assumptions on the errors for generalised linear models. The General linear model as the foundation for Analysis of Variance and Analysis of Covariance, including Multivariate models (MANOVA, ANCOVA, MANCOVA)
Parameter estimation Parametric inference and the Maximum likelihood estimate. The maximum likelihood estimator and its properties, including asymptotic normality. The method of moments for parametric inference.
Critical Analysis of Research Reporting the results of an experiment and Hypothesis test, communicating the meaning of a test to peers and colleagues from non-technical backgrounds, interpreting existing reports and academic papers.
Introduction to Statistics Packages The sue of standard statistical packages, including open-source software. R, Minitab and SPSS.

Indicative Assessment Breakdown	%
Course Work Assessment %	40.00%
Final Exam Assessment %	60.00%

Course Work Assessment %				
Assessment Type	*Assessment Description*	*Outcome addressed*	*% of total*	*Assessment Date*
Open-book Examination	Probability: The student will be set a number of questions on the theoretical, probability element of the module, including its application to problems such as reliability and quality control, the fundamental definitions of probability, the Central limit theorem and its implications, the properties and definitions of common distributions and the theory of the general linear model.	1,2	10.00	n/a
Practical/Skills Evaluation	Hypothesis testing I: The student will be given an assignment on Hypothesis testing, implementing a range of the statistical tests covered in the module, including tests on means and variances, tests on group means, correlation and regression, and tests for goodness-of-fit and independence. The student will be assessed on their ability to establish the conceptual framework of any test, the Null and alternative Hypothesis, identify the parameters of a given test and draw the correct conclusions and the meaning of type I and II errors.	2,3	10.00	n/a
Practical/Skills Evaluation	Hypothesis testing II: The student will be given an assignment on Analysis of Variance, where they will identify a range of experimental designs testing scientific Hypotheses, the corresponding test and the required partitions of sums of squares for the analysis of variance layout. The student will be assessed on their ability to establish the conceptual framework of the tests and drawing the correct conclusions.	3,4,6	10.00	n/a
Case study	Interpreting the results of an analysis of an existing or historical data set, writing up a report at an appropriate academic standard on these results, and interpreting them for peers and non-technical colleagues.	4,5,6	10.00	n/a

No Final Exam Assessment %

Indicative Reassessment Requirement
Repeat examination *Reassessment of this module will consist of a repeat examination. It is possible that there will also be a requirement to be reassessed in a coursework element.*
Reassessment Description The repeat arrangements will typically involve similar assignments for the continuous assessment component as were delivered in the normal semester.

ITB reserves the right to alter the nature and timings of assessment

Indicative Module Workload & Resources

Indicative Workload: Full Time	
Frequency	**Indicative Average Weekly Learner Workload**
Every Week	24.00
Every Week	24.00
Every Week	20.00
Every Week	12.00
Every Week	20.00

Resources

Recommended Book Resources

GM Clarke & D Cooke 2004, *A Basic Course in Statistics*, Oxford University Press,

Rouncefield & Holmes 1993, *Practical Statistics*, Centre for Statistical Education Sheffiled UK

W Mendenhall, D Wackerly & R Scheaffer 1990, *Mathematical Statistics with Applications*, Duxbury Press

D Montgomery 1991, *Design and Analysis of Experiments*, Wiley & Sons

Chris Chatfield 1983, *Statistics for technology*, Chapman & Hall London [ISBN: 0412253402]

Supplementary Book Resources

Henk Tijms, *Understanding Probability*, Cambridge University Press [ISBN: 110765856X]

David A. Freedman, *Statistical models*, Cambridge ; Cambridge University Press, 2009. [ISBN: 0521743850]

This module does not have any article/paper resources

This module does not have any other resources

Module Delivered in

Programme Code	Programme	Semester	Delivery
BN_EMIOT_M	Master of Engineering in Internet of Things Technologies [BN535M 30 credits taught with a 60 credit research project]	2	Mandatory
BN_EMIOT_R	Master of Engineering in Internet of Things Technologies [BN535R 60 credits taught with a 30 credit research project]	2	Mandatory