Unit title: Analysis of Scientific Data and Information

Unit code: **F/601/0220**

QCF level: **4**

Credit value: **15**

Aim

This unit develops skills in mathematical and statistical techniques used in the analysis of scientific data, together with an understanding of the limitations in reporting results.

Unit abstract

In the 21st century, a considerable amount of data analysis is performed by computers. The importance of understanding how and in what circumstances to use individual mathematical and statistical techniques, and the significance of the results, is not diminished by the availability of computational facilities. The primary outcome of scientific experimentation frequently comprises data, the volume of which varies significantly depending on the type of work undertaken. Analysis of the data which is obtained needs to be processed in some way to extract meaning.

This unit aims to develop previous knowledge and understanding gained in learning about scientific data analysis and extend it to a level appropriate for use in industry and research. Starting with the fundamental procedures of displaying information and data to standards expected in the field of science, the majority of the unit focuses on the use of mathematical and statistical techniques in appropriate contexts. Treatment of these techniques is practical rather than theoretical.

Learners will examine how the outcomes of processing are used, in terms of values generated and their associated errors, to generate valid conclusions.

Learning outcomes

On successful completion of this unit a learner will:

1 Be able to present information and data to scientific standards

2 Be able to process data using numerical analysis

3 Be able to process data using statistics

4 Understand limitations in concluding results.

Unit content

1 Be able to present information and data to scientific standards

Presentation of information: target audience; fitness for purpose of media used; clarity of information; communication of work carried out

Display data: tabulation; bar charts; pie charts; frequency polygons; ogives; histograms; scatter diagrams

Graphical methods: linear axes; non-linear axes e.g. logarithmic, exponential; curve fitting; linear regression e.g. least squares method

2 Be able to process data using numerical analysis

Algebraic methods: transposing equations; linear equations; simultaneous linear equations; quadratic equations; roots of quadratic equations

Use of calculus: standard differentiation; first order derivatives of equations; applications of differential equations e.g. reaction rates; standard integration; definite integration; application of definite integration e.g. area under a curve

Errors in data: classification of sources of errors e.g. random, systematic, gross; difference between accuracy and precision; handling errors in data processing e.g. absolute, relative, compound

3 Be able to process data using statistics

Descriptive statistics: measures of central tendency e.g. mode, median, mean; measures of dispersion e.g. variance, standard deviation; coefficient of variation

Normal distributions: probability distributions; normal distributions; standardising; tests for normality; percentiles; samples of populations; standard error of the mean; confidence limits

Hypothesis testing: null hypothesis; alternative hypothesis

Statistical tests: type e.g. z-test, student's t-test, F-test, Pearson's chi-squared (χ^2) test, Pearson's product moment correlation coefficient; significance levels; power of the test; one-tailed and two-tailed

4 Understand limitations in concluding results

Total error in results: combination of component errors; representation of numbers; round-off errors; truncation errors; level of confidence in results obtained

Conclusions from the work: values of measured parameters; validity of hypotheses; support for theoretical models; confirmation of model developed; accuracy; precision of measurements

Information on the problem studied: fitness for purpose of the methods used; validity of conclusions; information provided on the systems studied; compatibility of results with those from other sources

Learning outcomes and assessment criteria

Learning outcomes **On successful completion of this unit a learner will:**	**Assessment criteria for pass** **The learner can:**
LO1 Be able to present information and data to scientific standards	1.1 create a plan for the presentation of scientific information 1.2 display data to scientific standards using planned methods 1.3 carry out graphical methods of displaying scientific data
LO2 Be able to process data using numerical analysis	2.1 perform numerical analysis on scientific data using an algebraic method 2.2 demonstrate numerical analysis using calculus on standard polynomial equations 2.3 evaluate absolute errors in scientific data
LO3 Be able to process data using statistics	3.1 perform descriptive statistics on a sample of continuous scientific data 3.2 demonstrate the nature of normal distributions using a sample of continuous scientific data 3.3 carry out hypothesis testing using standard statistical tests and draw conclusions
LO4 Understand limitations in concluding results	4.1 evaluate the total error in a sample of continuous scientific data 4.2 assess the accuracy of a model using the outcomes of processing carried out on experimental data 4.3 justify the validity of conclusion(s) from the information on a problem studied.

Guidance

Links

This unit has particular links with the following units within this qualification:

- *Unit reference number J/601/0221: Project for Applied Science*
- *Unit reference number R/601/0223: Work-based Investigation*
- *Unit reference number J/601/0297: Statistics for Experimental Design*

Essential requirements

Delivery

Delivery must focus on the application of mathematical or statistical techniques in science, rather than on the techniques themselves. Emphasis must be on the selection and implementation of methods appropriate to given scientific contexts, and on the evaluation of the significance of the results and conclusions obtained. Delivery must draw on data from experimental units within the programme of study and use experiments as models for design and analysis. Learners must be taught to use software correctly, and to appreciate both the strengths and limitations of the methods used.

Delivery teams should analyse the mathematical requirements of their programmes and select the set of techniques learners will need to derive meaning from the information and data they will encounter during their studies.

Assessment

Evidence for achieving this unit must be in a scientific context. Scientific terminology, protocols and documentation should be used where appropriate.

Learning outcome 1 involves presenting information and data to standards expected in the science industry.

Learning outcomes 2 and 3 involve the mathematical and statistical techniques commonly used in the process of scientific data analysis. Emphasis must be on the accurate application of the methods covered, rather than on demonstrating understanding of the mathematical concepts. Evidence should include case studies or experimental studies, where appropriate.

Learning outcome 4 involves the generation of a formal conclusion based on the outcome of the data analysis. Evidence may be integrated with evidence from the other three learning outcomes.

Resources

Learners will need access to IT facilities and appropriate software to enable them to tackle realistic problems. Many of the operations relevant to applied science programmes can be implemented using a generic spreadsheet package (such as Microsoft Excel). Ideally, this will be supplemented by dedicated mathematical or statistical packages, for example Minitab, PASW Statistics or MATLAB.

Employer engagement and vocational contexts

Learners will benefit from visits to industrial and research facilities to observe practical applications of data analysis, or to gain access to learning materials.

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