LEVEL 3

UNIT 3: Scientific analysis and reporting

Y/507/6150

Guided learning hours: 120

Essential resources required for this unit: Scientific calculator, access to science in the media.

This unit is externally assessed by an OCR set and marked examination.

UNIT AIM

The techniques presented in this unit underpin the work of scientists in the collection, analysis and presentation of data and information. The unit will develop your knowledge and understanding of a range of useful analytical techniques that can be applied in experimental and investigative settings. Techniques used in scientific experimentation and analysis must be valid, require the accurate and careful gathering of sufficient data and ultimately its interpretation and reporting.

This unit will build on the laboratory techniques from Unit 2 by adapting and extending these according to requirements and applications.

Scientists must produce reports on their scientific investigations designed to meet the needs of specific audiences. Their findings may be further reported on in the public domain such as in the media.

This unit will develop a learners reporting skills and evaluate those of others. They must report on the scientific techniques they have used, methods designed and selected to analyse the data they have collected and appropriate formats to present their findings.

TEACHING CONTENT

The teaching content in every unit states what has to be taught to ensure that learners are able to access the highest grades.
Anything which follows an i.e. details what must be taught as part of that area of content. Anything which follows an e.g. is illustrative.

For externally assessed units, where the content contains i.e. and e.g. under specific areas of content, the following rules will be adhered to when we set questions for an exam:

- a direct question may be asked about unit content which follows an i.e.
- where unit content is shown as an e.g. a direct question will not be asked about that example.

Learning outcomes The Learner will:	Teaching content Learners must be taught:	Exemplification
1. Be able to use mathematical techniques to analyse data	1.1 Application of basic arithmetic techniques, i.e.: • finding a mean, median, mode • correct rounding of values • use of appropriate SI unit • represent quantities in standard form • convert numbers between fractional, decimal and standard form • appropriate value of significant figures 1.2 Use of simple mathematical techniques, i.e.: • calculating percentage error • percentage yield • substitution in an equation • calculation of surface area and volume 1.3 Complex mathematical techniques, i.e.: • calculating rate • changing the subject of an equation • geometric progression (serial dilutions) • quantitative assessment of uncertainty • quantitative assessment of error • calculating variance and standard deviation	Learners should be familiar with the seven SI base units and with derived units (metre, kilogram, second, ampere, Kelvin, candela, mole). Refer to School Science Review The ASE's journal for science education 11–19; note: symbols for physical quantities are written in italic script (*F*, etc) symbols for units are written in roman script (N, etc) SI unit prefixes (m, etc) are written in the same script style as the units themselves. Learners should be able to present numbers to a given number of significant places and decimal places, and select the most appropriate in scientific calculations. Learners should understand the importance of using the correct mathematical order (i.e. brackets, order, division, multiplication, addition, subtraction – BODMAS), and should be able to express numbers in standard form. Learners should be able to use mathematical operations and a calculator confidently. Learners should be able to use powers, reciprocals and roots. Link the significant value to the accuracy of the data. Learners should be able to

Learning outcomes The Learner will:	Teaching content Learners must be taught:	Exemplification
		rearrange and solve simple formulae e.g. W = m g, make m the subject.
2. Be able to use graphical techniques to analyse data	2.1 Appropriate choice of graph, chart or diagram related to data, i.e.: • scatter graph • line graph • bar chart • histogram • pie chart • kite diagram 2.2 Draw linear and non-linear graphs from data i.e.: • continuous • discontinuous 2.3 Apply accuracy and precision to a graph, i.e.: • use of range bars • identification of outliers 2.4 Interpreting data through graphs i.e.: • fine values by interpolation and extrapolation • determine intercepts for graphs • calculating gradient of a line	When plotting a graph, learners must use appropriate scales and axes and plot the data accurately. Where appropriate, use of lines of best fit. Range bars would signify the range of results for a data point; outliers would also be identified. Main trends/patterns in the data are described in detail and interpreted correctly with reference to quantitative data and relevant scientific understanding. It may be necessary to describe different phases of the graph if this is relevant. Learners should be able to interpret data from graphs. Learners should be able to determine intercept points.
3. Be able to use keys for analysis	3.1 To use and construct a key to identify collected specimens 3.2 Use a key to compare the quality of primary data to secondary data 3.3 Classification system – rationale for classification of living things 3.4 Binomial nomenclature	Identification charts and dichotomous keys. Making judgements on the quality of data such as gases in the atmosphere or chemical composition of solutions such as purity of freshwater based on indicator species. Justify the need for a system which classified the natural world, e.g. consistency, accepted naming conventions, simplification of scientific names. Explain the construction of binomial nomenclature and how it ensures that each organism has a formal name, recognised universally eg the generic name (genus) and a specific name (species) for example *Homo sapiens*, *Ursusamericanus*

Learning outcomes The Learner will:	Teaching content Learners must be taught:	Exemplification
4. Be able to analyse and evaluate the quality of data	4.1 Define and apply terms commonly used in experimental analysis and evaluation 4.2 Discuss the quality of data, i.e.: • identify relationships between variables • level of uncertainty of data, including anomalous results • sources of error • instrument error • measurement error • systematic error • random error • accuracy of measurements • precision • range and interval • repeatability • reproducibility	Learners should be able to use terminology such as accuracy, precision, repeatability, reproducibility, uncertainty and validity. Where ever possible use quantitative data not qualitative statements – e.g. result was within 5% of given value. Sources of error may be due to instrument malfunction or out of calibration or purely random or the lack of sensitivity, resolution or magnification. Sources of error in reading measurements, for example, position of eye line when reading an instrument. Improvements in the quality of the data may be obtained using an alternative instrument of greater sensitivity, resolution or magnification. What is the quality and accuracy of the data – how close are the results/primary data to the secondary data. What was the range/precision of the results - were the repeats close together.
5. Be able to draw justified conclusions from data	5.1 Conclusion given and justified, i.e.: • comparison between primary and secondary sources of information • identification of conflicting evidence • further evidence required to make the conclusion more secure	Learners should understand the reasons for comparing experimental results with secondary data sources. A comparison between results and secondary data should be made and reasons for similarities or differences suggested. Give an explicit link between the description of the pattern/trend and the data from which it is derived. The explanation of the trend/pattern must be backed by science. Any anomalies in the data should have been identified and taken into account.

Learning outcomes The Learner will:	Teaching content Learners must be taught:	Exemplification
6. Be able to use modified, extended or combined laboratory techniques in analytical procedures	6.1 Modify microscopic analytical techniques according to need, i.e.: • Use of alternative staining procedures in microscopy • Preparation of permanent slides	Learners should be able to develop the laboratory techniques that they have used to improve the quality of the collected data.
	6.2 Adaptation of chromatographic techniques, i.e.: • Use of column chromatography and thin-layer chromatography (TLC) as a preparative and quantitative technique • Use of TLC as a quantitative technique by elution or densitometry	Building on TLC as a separation techniques used in Unit 2, learners will collect samples of separated compounds for further analysis. Spots can be scraped from a TLC plate and eluted or densitometry used as a quantitative technique. Densitometry should focus on the principles of the technique.
	6.3 Use of alternative titration techniques, i.e.: • Precipitation titrations, i.e. determination of chloride • . Redox titrations, i.e. standards to include potassium dichromate, iodine solution, sodium thiosulfate. • Complexinetric techniques i.e. EDTA	Learners will be familiar with acid-base titrations but should extend the principles of finding unknown concentrations of chemicals using other types of chemical reactions. For example learners might carry out Cl^- in seawater as a precipitation titration. Analyses could include hydrogen peroxide in hairdressing or mouthwash, hypochlorite in bleach, iodine number of fats and oils, peroxide number of edible oils, sulfur dioxide in wine, vitamin C content.
	6.4 Select and use chemical, i.e.: analytical techniques with improved specificity • Tests for cations and ions i.e.: thiocyanate for iron(III) • Adaptation as quantitative techniques i.e.: iron(III) by colorimetry (thiocyanate) and iron(II) by spectrophotometry (1, 10–phenanthroline)	Learners will be familiar with qualitative tests for ions from Unit 2 and their often lack of specificity. Ions that give specific colours with reagents can be used in their quantitative estimation. For example quantitative adaptation techniques could apply to colorimetry and/or spectrophotometry.

Learning outcomes The Learner will:	Teaching content Learners must be taught:	Exemplification
	6.5 Use of a combination of techniques for bacterial identification, i.e.: Colony morphology Staining techniques Growth and behaviour on differential, selective and enriched media	Learners have grown bacteria in Unit 2 but will now use a combination of techniques that will enable, at the least, tentative identification of a species of bacterium.
7. Be able to record, report on and review scientific analyses	7.1 Methods of recording data, i.e.: Notebooks, logbooks Tables Graphs Photographs and sketches Video Audio 3D representations, e.g. of crime scenes Modelling, e.g. GIS geographical information system for terrain, fossil organisms 7.2 Reporting data, findings and other scientific information, i.e.: • Reporting to a chosen audience (peers, public, scientific community) • Reporting by the scientific media i.e. public information scientists; science journalists 7.3 Evaluating the reporting data, findings and other scientific information, i.e.: • Status and affiliation of author(s) • Publication or information source in which data reported • Nature of data and scientific findings reported, i.e. validity of study and data, accuracy, quality of science explanations • Quality of reporting, i.e. clarity, conciseness, appropriate to intended audience	Learners should understand that methods of recording data will depend on the type of analysis to be carried out. They should be able to give examples of the best choice of method for different types of data. Scientists normally use tables to record data, but often record data direct onto graphs to identify outliers. Alternatively data can be presented as an artefact itself e.g. a chromatogram. They use different types of graphs to present and analyse data. Public information scientists include universities, government agencies, forensic science agencies, research organisations, science and technology companies and museums. Science journalists are authors of science books, newspaper articles, magazine articles, TV programmes, Internet news sites, wikis, vlogs and blogs Learners should consider whether the reporter is reporting primary or secondary data. They should appreciate the importance of the peer review of articles for publication for the scientific community. Learners should be able to compare and evaluate the quality of data and reports produced by their peers and by the scientific media.

LEARNING OUTCOME (LO) WEIGHTINGS

Each learning outcome in this unit has been given a percentage weighting. This reflects the size and demand of the content you need to cover and its contribution to the overall understanding of this unit. See table below:

LO1	10-20%
LO2	10-20%
LO3	10-20%
LO4	10-20%
LO5	10-20%
LO6	10-20%
LO7	5-15%

ASSESSMENT GUIDANCE

All Learning Outcomes are assessed through externally set written examination papers, worth a maximum of 100 marks and 2 hours in duration.

This unit is externally examined. Teachers are advised to obtain sample examination papers available from the OCR website. Examination papers typically contain six questions covering the learning outcomes presented in the unit specification. Problems are presented to learners using a range of styles, including short answer, calculation, fill the blanks, matching, true/false, longer essay type questions etc. Problems are presented in a scientific context.