London South Bank University

Analytical Techniques

Module Ref. EAA_5_421

Moodle site: Analytical Techniques

Faculty of Engineering Science and the Built Environment

2015/16

become what you want to be

CODE OF CONDUCT
FOR
LECTURE THEATRES AND CLASSROOMS

The behaviour and conduct in lecture theatres and classrooms should be conducive to teaching and learning for all participants.

Students not adhering to this code will be asked to leave and persistent offenders may be subject to the University's disciplinary procedures.

A lecturer has the right to end a teaching session if this code is significantly breached.

Code	
1	**Students are expected to show consideration towards others at all times.** • Talking should be kept to a minimum when a lecture is in progress. • Shouting or other forms of distracting behaviour of any kind is not permitted.
2	**Students will not be allowed to enter the lecture theatre or classroom 15 minutes after the scheduled start.** • Latecomers should wait until a *scheduled break* before joining the class.
3	**Entering and leaving a room during a lecture is not allowed.** • Students should not leave the room during a lecture. • The breaks between lectures are the time to use the toilet facilities. You will be told when a break begins .
4	**Your attention is required throughout the lecture.** • Students who cannot give the lecturer their full attention, or who prefer to do something else, should not be in the lecture and will be asked to leave.
5	**Mobile phones and MP3 players *must* be switched off.** • You will need to bring a proper calculator to the teaching sessions.
6	**You are not allowed to record the lecture without the lecturer's permission.**
7	**Browsing the internet using a laptop computer during a lecture is not permitted unless advised by the lecturer / tutor.**
8	**Wait quietly outside a room when a lecture or examination is in progress.**
8	**Tutorials require students to participate in discussions, exercises or other activities.** • If you do not intend to participate, or have not done the preparatory work, do not attend.
9	**Students are forbidden from operating the audio visual equipment in the teaching rooms.**
10	**Computer terminals and other equipment should be used in the appropriate manner and only to meet the learning outcomes of the session.** • Terminals should not be used during a class for accessing material not relevant to the exercise.
11	**Eating during a lecture is not permitted.**
12	**Remove your waste when you leave.**

Attendance

Experience has shown staff that there is a clear link between students' attendance at classes and overall module mark (and ultimately degree classification).
Although supplementary material and/or lecture slides may be posted on module Moodle sites, this is not a substitute for attendance.
You will not be allowed to submit coursework relating to sessions you have not attended. This could result in failure of the module!
A **minimum** of 80% attendance at all sessions is expected for successful completion of a module, although you should be aiming for 100%.
For some modules, your final mark may be linked to your attendance (see module guide for details).

Please Note

It is important to attempt to pass **all** assessments at the first attempt.

Students **do not** have a right to referral - this can only be given by the Examination Board when it considers your entire collection of marks at the end of each academic year. Additionally, you should note

1. That a referred element of assessment (coursework or examination) will be capped at 40%
2. That you will be allowed only one attempt at referral
3. That a failure in a referral may require you to re-take the entire unit, attend for a second time and take all assessments, even those elements you may have previously passed. **You will be charged again for that unit.** (Currently, just over £2000 for a 30 credit module).
4. The University regulations do not allow you to progress to the next level, or be given a qualification, with a number of units outstanding or with certain units outstanding.

If you need any clarification you should consult your Course Guide or speak with your personal tutor, year tutor or Course Director.

Table of Contents

"This guide is designed to help you structure your learning by providing an indicative structure and content for the module. It is a guide and not a definitive statement of what you will be taught. We will try to follow this published schedule as far as possible, but there may be some variation as the module develops and as we try to match the pace and content of our teaching to student needs."

1. MODULE DETAILS

Module Title:	Analytical Techniques
Module Level:	5
Module Reference Number:	FBS_5_200
Credit Value:	15
Student Study Hours:	150
Contact Hours:	50
Private Study Hours:	100
Pre-requisite Learning (If applicable):	
Co-requisite Modules (If applicable):	
Year and Semester	Year 2, semester 1
Module Coordinator:	Dr Nicholas Power
UC Contact Details (Tel, Room, Email)	Tel: 0207 815 7956 Room: J506 Email: Nicholas.power@lsbu.ac.uk
Teaching Team & Contact Details (If applicable):	John Acord: acordj@lsbu.ac.uk J506; tel: 020-7815-7922 Dr Amar Aouzelleg: aouzella@lsbu.ac.uk J504: Phone: 0207 815 7945 Dr Chris Brock: brockc@lsbu.ac.uk J504: Phone: 0207 815 7970 Dr Suela Kellici: kellicis@lsbu.ac.uk MXXX Phone: 0207 815 7983 Dr Delia Ojinnaka: ojinnad@lsbu.ac.uk J504: Phone: 0207 815 6255 Dr Michael Byford: michael.byford@lsbu.ac.uk J504: Phone 0207 815 XXXX
Subject Area:	Food & Bioscience, and Forensics
Summary of Assessment Method:	Coursework (50%). Exam (50%)

2. SHORT DESCRIPTION

Modern analytical laboratories house a wide range of analytical instrumentation, which facilitate the detection of a vast array of analytes and, often, their quantification down to ppb or ppt levels. Irrespective of how sophisticated the instrumentation may be, if it is not used correctly, the results obtained will, at best, be of questionable reliability. It is essential that the analyst understands the limitations of each method.

The module aims to explain the theoretical basis underpinning the main classes of analytical instrumentation found in most analytical laboratories. Examples of the applications of each technique, together with explanations of the calculations required in order to interpret the results are given. Students will gain hands on experience in the use of most of the methods.

In this Module Guide we spell out the aims and outcomes (what you should be able to do by the completion of the module). You should use these regularly to check on your own progress.

3. AIMS OF THE MODULE

- To provide a body of knowledge relevant to the principles of instrumental methods and techniques employed in the quantification and analysis of foods and biological materials and in forensic science.
- To provide concepts relevant to the principles and applications of the more sophisticated methods of analysis.
- To provide an awareness and demonstrate new analytical techniques relevant to modern forensic and analytical laboratories.
- To acquire an understanding of the principles and practice of modern techniques for determining the identity and quantity of molecules of forensic and analytical interest.
- To provide information to enable students to make reasoned choices in the employment and application of analytical techniques in applied, industrial and environmental biology, in the analysis of foods and in forensic science.
- To foster group work skills and encourage self assessment and reflection.

4. LEARNING OUTCOMES

4.1 Knowledge and Understanding

On completion of this module students should be able to:

- describe the principles of a variety of analytical methods
- use various analytical instruments and interpret the data generated
- select and justify choice of an analytical method for a range of different analytes
- research information, evaluate results and compile a report on practical exercises carried out.
- Students should be able to show an understanding of the many ways that computers are of use in an analytical context.
- Students should be able to show how the identity and quantity of molecules of forensic and analytical interest can be derived by the use of modern analytical techniques.

4.2 Intellectual Skills

Students who fully participate in this module will further develop the following skills:

- *Communication skills*; oral communication skills are developed in tutorial and practical classes and written communication skills in practical reports and the essay.
- *Numeracy skills*; these will form an important part of the tutorial exercises and will also be involved in the processing of the data acquired in the laboratory sessions.
- *Use of information and communication technology*; Use of electronic sources of information will be valuable for both writing the introductions to practical reports and in the essay. Use of word-processing and spreadsheet packages (for presentation of graphical data) is required when writing laboratory reports.
- *Learning how to learn*; the key aspects in this module are time management to ensure all submission deadlines are met, the ability to collect the information required for all the written elements of assessment and the discipline to concentrate on essential rather than peripheral aspects of the subject.
- *Understanding of methodologies*; an essential aspect of this module is to acquire a broad knowledge of instrumental methods of analysis and the situations in which different methods are applicable.
- *Ability in critical analysis*; another important aspect of this module is the coursework essay where the relative advantages and disadvantages of different instrumental methods for your chosen analyte are discussed and evaluated.
- All of the above will enhance the student's personal development plan.

4.3 Practical Skills

Students will build on the laboratory experience developed in year 1.

- routinely apply health and safety precautions in the laboratory.
- work effectively, both individually and in a group, to follow a schedule.
- demonstrate accurate and reliable technique in gravimetric and volumetric methods of sample and standards preparation.
- demonstrate correct use of sophisticated analytical instrumentation.
- Interpretation of results from analytical instrumentation

4.4 Transferable Skills

All of the above intellectual and practical skills

Study Skills

- take useful notes from lectures and core reading material
- develop and carry out a workable personal plan to meet deadlines and carry out exam revision
- find references in the library and use the interlibrary loan system
- write up laboratory reports in the required format
- use your problem-solving skills in a wide variety of situations

5. ASSESSMENT OF THE MODULE

Important: Your final mark for this module is linked to your attendance. See the instructions on page 21.

There are two elements of assessment. You must pass ALL elements of assessment to pass the module.

Staff will aim to give feedback to students within 15 working days after the submission of an assignment.

5.1 Coursework (50%): Practicals & Mid-Semester Tests.

The assessment for the practical component of this unit consists of a portfolio of write-ups of the 5 main practical exercises (excludes the week 1 expt.)**.** Details are given below:

Mid-Semester Tests: These may be presented as either an in-class test or as an online MCQ via Moodle. This will worth 10% of the module marks.
Report 1: You must write up the experiment that you do in week 2. This will be marked and returned to you within 15 working days. This should be written as a full lab report, following the guidelines given in the 'Standard Format for Laboratory Reports' section below.
This report will be worth 30% of the marks awarded for the lab-work component of the module assessment.
Remember, marks are awarded for the relevance and accuracy of the content of your reports, NOT for quantity. Please read the section, starting on page 8, giving details of what is expected in a lab report.

Report2: Using the feedback from report 1, you **must** submit full reports for **ALL** of the remaining experiments, within 2 weeks of the date of your last experiment. **One** of these reports will be selected at random and marked.

This report will be worth 70% of the marks awarded for the lab-work component of the module assessment.

Your work will not be marked unless ALL the reports have been submitted.

ALL reports MUST be submitted via TurnItIn, using the link on the module Moodle site.
DO NOT submit printed copies of your reports. Only electronically submitted reports will be marked.

Each topic includes a number of questions which you can use as a guide help when deciding what to include in the introduction and critique. Bear in mind the word limits – you will not be able to answer every question.

Reports **MUST** be word-processed, following the standard format detailed in the

laboratory book.

NOTE: there are different deadlines for submission of the portfolio of work depending on when you carry out the practicals.
For students carrying out the practicals in **weeks 1 to 6**, the deadline is **23.59hrs on Sunday 15th November 2014**
For students carrying out the practicals in **weeks 7 to 12**, the deadline is **23.59hrs on Sunday 4th January 2015**

5.2 Exam (50%) – ALL students

An end of semester examination will assess students' ability to analyse experimental data, and the learning outcomes of current aspects of the course, as presented in the lectures, guided reading, and tutorial problems.

6. INTRODUCTION TO STUDYING THE MODULE

6.1 Overview of the Main Content

The information given in this section is **indicative** of the material that may be covered; it is not a definitive list.

Principles of Analysis
Review the requirements and limitations of analytical methods. Validity of analytical data. Precision, accuracy, sensitivity, interferences, bias. Standard and certified reference materials. Criteria for the selection of an analytical method.

Sampling Methodology
Review the methods available for sampling and sample preparation and storage. Systematic and random sampling. Selection of sampling method.

Instrumental Methods of Analysis (80 % of module time)
Review the principles and practice of instrumental methods of analysis. Discuss the applications and limitations of these techniques. Interpret the analytical data generated by these techniques.

Chromatographic methods. Ultraviolet, visible, fluorescence and infrared spectroscopy. Atomic spectroscopy. Electrophoresis. Electrochemical methods. Biosensors. Radiochemical techniques. Mass spectrometry.

Semester 1 will focus on the theoretical basis of the main instrumental techniques, found in most analytical laboratories. Semester 2 will look at some of these techniques in more detail and introduce some of the more specialised techniques and latest developments in analytical instrumentation.

6.2 Overview of Types of Classes

The teaching and learning methods employed in this module will include lectures, tutorials, practical classes and private study time.

Lecture time will be used in a variety of ways e.g. to introduce a topic, for group topic work, for discussion sessions and for working on interactive handouts.

Tutorials will concentrate on the interpretation of analytical data and problem solving.

Practical classes will focus on the practical application of the techniques and encourage good laboratory practice and group work skills.

The remaining module time (100 hours) will be used for private study, for guided reading, student centred learning and completing coursework.

Warning: Due to the number of students on the course and the limits on the number of analytical instruments available for laboratory practicals, you will **NOT** be able to attend an alternative session if you miss your timetabled slot in the laboratory.

6.3 Importance of Student Self-Managed Learning Time

The lectures and tutorials can only give you an introduction to the topics covered. In order to gain the maximum benefit from this module, it is important that you read the recommended texts and prepare **in advance** for the practical sessions and the tutorials. Read the laboratory schedules **before** arriving at the class and ensure you understand aims of the experiment and how to carry out any calculations that may be required. Make use of the materials provided on the Moodle site. The essay will require a substantial amount of self-lead research; the reading list provided at the end of this module guide is only a starting point for your research.

6.4 Employability

The practical skills you will (hopefully) acquire as a result of completing this module will be of value for any future employment in a laboratory environment, whilst the intellectual skills will be transferable to any area of employment.

Continued…

7. THE PROGRAMME OF TEACHING, LEARNING AND ASSESSMENT

7.1 Semester 1: Indicative lecture timetable. This list, and details on following pages,is subject to change, due to staff changes and review of topics. Changes will be posted on the module Moodle site.

Irrespective of changes to topics, or lecturer, sessions will run **every** Monday, 3-5pm, in NHLT.

Week Number	Topic	Lecturer
1	Introduction to the module Sampling Methods	Dr N Power
2	Chromatography	Dr N Power
3	Chromatography	Dr N Power
4	GC	Dr N Power
5	HPLC	Dr N Power
6	Absorbance Spectroscopy	Dr N Power
7	Absorbance Spectroscopy Laboratory Work Atomic Spectroscopy	Dr N Power
8	Atomic Spectroscopy Fluorescence Spectroscopy	Dr S Kellici
9	Electrochemistry & Ion Selective Electrodes	Dr N Power
10	Ion Selective Electrodes Biosensors	Dr N Power
11	Electrophoresis	Dr J Acord
12	Mass Spectrometry	Dr N Power

7.2 Lecture topics (semester 1)

Week 1 Introduction to the Module (Dr N Power)

This session will give an overview of the module, including a brief introduction to the aims, objectives and learning outcomes, a description of the general module structure, the programme of teaching and learning, the use of resources, assessment requirements and evaluation procedures.
Core reading: The Module Guide

2. Sampling Methods (Dr N Power)

Accurate sampling and sample storage and treatment prior to the analysis is a crucial stage in an experiment. The sample that is taken from a bulk must be representative and storage must ensure that no changes (loss or contamination) take place.

This session will be used to describe how sampling and sample storage is carried out to ensure, as far as possible, that the end result of the analysis is representative of the bulk of the material.
Core reading:

- Reed R, Holmes D, Weyers J. and Jones A., (2003), *Practical skills in Biomolecular* Sciences, chapter 30.
- Potter G.W.H. (1995), *Analysis of biological molecules. An introduction to principles, instrumentation and techniques*. +Chapters 1 and 2.

Week 2 & 3 Chromatographic Principles (Dr N Power)

Biological samples are complex mixtures of many compounds. In order to quantify for any particular compound, it is often necessary to carry out a separation stage first. Thin layer chromatography is one example of a separation technique. The principles of this traditional technique have been used to develop sophisticated automated instruments that allow separation followed by on line detection and quantification.

This session will be used to introduce the principles of chromatography (partition, adsorption, ion exchange and affinity). The apparatus used to carry out chromatography (gas chromatography and high performance liquid chromatography) will be described.

Core reading:

- Student centred open learning Module 2 *Chromatography*.
- Faust C.B. (2001), *Modern chemical techniques.* Royal Society of Chemistry. Chapter 5.
- Reed R.,Holmes D, Weyers J. and Jones A., (2003), *Practical skills in Biomolecular*. Sciences, chapter 44 or *Practical skills in Biology,* chapter 60. (See optional reading list.)
- Potter G.W.H. (1995), *Analysis of biological molecules. An introduction to principles, instrumentation and techniques*. Chapter 5.

Week 3 Chromatographic Methods (Dr N Power)

GLC and HPLC are the two most used chromatographic methods, but which of the two should you use for a given separation problem? What are the criteria by which you should make a choice of methods?

Core reading:

- Student centred open learning Module 2 *Chromatography*.
- Faust C.B. (2001), *Modern chemical techniques.* Royal Society of Chemistry. Chapter 5.
- Reed R.,Holmes D, Weyers J. and Jones A., (2003), *Practical skills in Biomolecular*. Sciences, chapter 45 or Practical *skills in Biology,* chapter 60. (See optional reading list.)
- Potter G.W.H. (1995), *Analysis of biological molecules. An introduction to principles, instrumentation and techniques*. Chapter 5.

Week 4 Absorbance Spectroscopy (Dr N Power)

Many compounds in food and biological samples are coloured and absorb radiation in the visible region of the spectrum. Yet more compounds are colourless but will absorb in the ultraviolet region. This absorbance is commonly used to quantify for the compound under analysis, often after prior separation by HPLC.
The aim of this session is to introduce the theory of the absorbance of ultraviolet and visible radiation by molecules in solution. The Beer-Lambert Law will also be explained.
This session will be used to describe the instruments that are used in Absorbance Spectroscopy and to investigate sources of error. What are the component parts of an absorptiometer? What instrumental errors are associated with the technique? How can we ensure that the result is accurate and precise?

Core reading:

- Student centred open learning Module 4 *Ultraviolet and visible molecular absorbance spectroscopy*, unit 1.
- Faust C.B. (2001), *Modern chemical techniques.* Royal Society of Chemistry. Chapter 4.
- Reed R.,Holmes D, Weyers J. and Jones A., (2003), *Practical skills in Biomolecular*. Sciences, chapters 40 & 41 or *Practical skills in Biology,* chapter 59. (See optional reading list.)
- Potter G.W.H. (1995), *Analysis of biological molecules. An introduction to principles, instrumentation and techniques*. Chapter 3.

Week 5 Atomic Spectroscopy (Dr N Power)

Atomic spectroscopy is the most commonly used method for the analysis of trace elements (metals and metalloids) in biological samples. These elements may be of nutritional importance or may be toxic contaminants. The ability to analyse accurately at very low levels is of critical importance.

This session will be used to investigate the principles and practice of atomic spectroscopy. Special attention will be paid to sources of error in trace element analysis.

Core reading:

- Handout on Atomic Spectroscopy.
- Reed R.,Holmes D, Weyers J. and Jones A., (2003), *Practical skills in Biomolecular*. Sciences,chapter 41.
- Potter G.W.H. (1995), *Analysis of biological molecules. An introduction to principles, instrumentation and techniques*. Chapter 3.

Week 6 Fluorescence Spectroscopy (Dr S Kellici)

Some compounds that absorb ultraviolet radiation will then emit radiation. This process is called fluorescence. An example of a fluorescing compound is quinine, the bitter flavour added to tonic water. If you look closely at a bottle of tonic water, you will see a blue sheen caused by the fluorescence of quinine.

This session will be used to describe the principles of fluorescence spectroscopy, the instrumentation used and examples of its applications in biology and food science.

Core reading:

- Student centred open learning Module 5 *Fluorescence spectroscopy*.
- Reed R.,Holmes D, Weyers J. and Jones A., (2003), *Practical skills in Biomolecular*. Sciences, chapter 41.
- Potter G.W.H. (1995), *Analysis of biological molecules. An introduction to principles, instrumentation and techniques*. Chapter 3.

Week 7 Ion selective electrodes (Dr N Power)

Ion selective electrodes are used to quantify inorganic ions in solution. The most common example is the pH electrode, but there are others that are routinely used. These electrodes are sensitive, selective and non destructive but can give very inaccurate and non-repeatable results.

The aim of this session is to introduce the principles of ion selective electrodes and the Nernst equation. Group discussion will be used to describe some advantages and disadvantages of ion selective electrodes in comparison to other methods of analysis for example analytes.

Core reading:

- Student centred open learning Module 9 *Ion selective electrodes*.
- Potter G.W.H. (1995), *Analysis of biological molecules. An introduction to principles, instrumentation and techniques*. Chapter 4.

2. Biosensors (TBC)

Biosensors are analytical tools that combine the sensitivity and selectivity of an enzyme reaction with a transducer to generate an electrical signal. The ion selective electrode can be used as a transducer. This session will describe the types of transducers that are used with examples of importance in the food and biological sciences.

Week 8 Infrared Spectroscopy (Nick Power)

Infrared spectroscopy is most often used to aid in the identification of an unknown compound. The method is not very sensitive but is non-destructive and the analyte can be recovered for further analysis. The aim of this session will be to give an overview of the principles of the absorbance of infrared radiation by molecules and to explain why the absorbance data can be used for diagnostic purposes. The instrumentation used will be reviewed. An interactive handout is available on request.

Core reading:

- Faust C.B. (2001), *Modern chemical techniques.* Royal Society of Chemistry. Chapter 3.
- Reed R.,Holmes D, Weyers J. and Jones A., (2003), *Practical skills in Biomolecular*. Sciences, chapter 42.
- Potter G.W.H. (1995), *Analysis of biological molecules. An introduction to principles, instrumentation and techniques*. Chapter 3.

Week 9 Electrophoresis (Dr J Acord)

Electrophoresis is an important analytical technique for the separation of charged species, especially proteins. It is also an important tool in the human genome project. The aim of this session will be to describe the principles of electrophoresis and the instrumentation used.

Core reading:

- Potter G.W.H. (1995), *Analysis of biological molecules. An introduction to principles, instrumentation and techniques*. Chapter 6.
- Reed R.,Holmes D, Weyers J. and Jones A., (2003), *Practical skills in Biomolecular*. Sciences, chapter 46.

Week 10 Mass Spectrometry (Dr N Power)

Mass spectrometry is often described as the ultimate analytical tool. It provides a wealth of data about the structure of a compound that aids in identification and it can be used quantitatively at nanogram or picogram levels. It can be used alone or

interfaced to an HPLC or GLC or in conjunction with atomic spectroscopy. It can be used to analyse compounds as diverse as proteins and trace elements. This session will be used to introduce you to the principles of mass spectrometry especially GLC-MS and HPLC-MS and to explain how mass spectral data are presented and used for qualitative and quantitative analysis.

Core reading:

- Faust C.B. (2001), *Modern chemical techniques.* Royal Society of Chemistry. Chapter 1.
- Reed R.,Holmes D, Weyers J. and Jones A., (2003), *Practical skills in Biomolecular*. Sciences, chapter 42.
- Handout on Mass Spectrometry.

Week 11 Data Handling and Data Storage (Dr N Power)

This session will be used to investigate the benefits of linking microcomputers to UV, IR and mass spectrometers. The applications covered will include;
(i) processing, display and storage of data, (ii) control of instrumentation, (iii) use of spectral databases and pitfalls and(iv) other applications, hardware considerations, LIMS.

2. Introduction to Nuclear Magnetic Resonance Spectroscopy (NMR)
NMR is another important instrumental method, used mainly for qualitative identification of organic molecules. We will consider only proton NMR which is used to investigate the environment of protons and how they are attached to the carbon skeleton of the molecule.

3. Qualitative Analysis involving a combination of spectroscopic methods
Most of the analytical methods that have been previously described are routinely used for quantitative analysis of previously identified analytes. However, sometimes we want to know the identity of an unknown.

The techniques of UV-Visible absorption, infra-red, NMR and mass spectroscopy can be used together as a very powerful set of techniques for the elucidation of molecular structures. The information derived from each technique will be considered and a set of problems will be discussed.

Core reading

- Skoog D.A. and Leary J.J. (2001), *Principles of Instrumental Analysis*, 4ed Saunders College Publishing Chapter 3
- Faust C.B. (2001), *Modern chemical techniques.* Royal Society of Chemistry. Chapter 2.
- Reed R.,Holmes D, Weyers J. and Jones A., (2003), *Practical skills in Biomolecular*. Sciences, chapter 42.

Week 12 Radiochemistry (Nick Power)

Radiochemical methods of analysis are very sensitive but potentially hazardous and costly techniques. This session will cover the principles of radiochemical methods

of analysis, describe the commonly used methods and their applications and compare the advantages and disadvantages of these methods with alternative techniques.

Core reading:

- Handout on radiochemistry.
- Potter G.W.H. (1995), *Analysis of biological molecules. An introduction to principles, instrumentation and techniques*. Chapter 7.
- Reed R., Holmes D, Weyers J. and Jones A., (2003), *Practical skills in Biomolecular*. Sciences, chapter 39.

7.3 Tutorial programme

Tutorials for this module will concentrate on the interpretation of analytical data and problem solving. These tutorials are designed to underpin the interpretation of data generated in the laboratory sessions.
You will need to understand how to carry out the calculations explained in these tutorials in order to write-up the laboratory exercises, so it is in your interests to ensure that you attend.

A separate booklet will be issued to all students, containing the exercises that will be covered in the tutorial sessions. It is essential that you bring this booklet to all the tutorial sessions.

7.4 Practical programme

Students who do not attend lectures and tutorials will not normally be allowed to attend practical classes.

There will be two groups for Forensic students (weeks 1 to 6) and four practical groups for the Bioscience/Food students (weeks 7-12). The group that you are in will depend upon the timetable of other modules that you are taking.

Students will work in pairs and carry out six practicals on a circus basis.

The circus plan will be organised in the lecture in week 1 (Forensics) and Week 5 (Bioscience & Food). You must attend the session for which you are timetabled. You cannot swap between sessions if you miss a practical.

Details of the practicals are given in a separate booklet.

7.5 Assessment

In order to pass the module students are expected to attend and actively participate in all elements. Students who do not participate in the lectures and tutorials will not normally be allowed to attend the practicals.

The maximum mark you can achieve for the module is linked to your attendance.

Your overall mark will be multiplied by your attendance/100 i.e. if you only attend 50% of the timetabled sessions (lectures, tutorials and labs) the maximum you can score is 50%.

Example:

course work 67%, attendance 65%

final mark = 67 *(65/100) = 44%

This module will be assessed by **two** elements:

- The first element of assessment will be based on the laboratory work. Students are required to attend **ALL** the laboratory sessions and keep a full record of the experiments carried out. Full details of the requirements for this component are given in section 5.1 above. (50%)

- The second element of assessment will be an end of semester exam. (50%)

7.5.1 Format and mark distribution of laboratory reports

Reports must use the standard format detailed in section 10 of this guide and also in the laboratory book. Failure to follow this format will result in loss of marks.

Your report should contain the sections listed below

a) Abstract 5% of marks

b) Introduction 25 % of marks

c) Methods 15 % of marks

d) Results 20 % of marks

e) Discussion 25 % of marks

f) Conclusions 5 % of marks

g) References

The remaining 5 % of the marks will be awarded for presentation. For example: Have you used tables and figures to their full advantage? Are they numbered? Do they have a title? What about spelling mistakes? Crossing-out? Clarity of calculations?

8. STUDENT EVALUATION

No questions on the unit review survey scored below 3. Students liked the laboratory exercises but some asked for more support from teaching staff out-side of the timetabled sessions. Staff will always endeavour to meet with individual students, or small groups, by prior arrangement if requested to do so. Additional materials will be posted on the unit Moodle site, where this is appropriate.

9. LEARNING RESOURCES

9.1 Core Materials

Faust C.B. (2005), *Modern chemical techniques.* Royal Society of Chemistry. (Reprinted 2005) ISBN 0-854-04286-5

Levinson, R. (2001). *More modern chemical techniques.* Royal Society of Chemistry. ISBN 0-854-04929-0

Reed R., Weyers J., Jones A. and Holmes D. (2007). *Practical skills in Biomolecular* Sciences (3rd Ed.), Pearson Education Ltd. ISBN 0132391155.
Note: there is a growing number of books in this 'Practical Skills in..' series, any one of which is suitable. For further details see the publishers web-site http://www.pearsoned.co.uk/bookshop/index.asp

Rubinson K.A. and Rubinson J.F. (2000). *Contemporary Instrumental Analysis.* Prentice Hall. (Dorling Kindersley). ISBN 0137907265.

Skoog D.A., Holler F.J., Crouch S.R. (2007). *Principles of instrumental analysis. 6th Ed.* Thomson Learning. ISBN 9780495125709

SCOL series: Daniels S.C. (1992), Student Centred Open Learning, LSBU.
Module 2: *Chromatography.*
Module 3: *Electrophoresis.*
Module 4: *Ultraviolet and visible molecular absorbance spectroscopy.*
Module 5: *Fluorescence spectroscopy.*
Module 6: *Infrared absorbance spectroscopy*.
Module 9: *Ion selective electrodes.*
These modules are available on the Analytical Techniques Moodle site

9.2 Background reading list

F.W. Fifield and D. Kealey. (2000). Principles and practice of analytical chemistry. 5th ed. Blackwell Science. ISBN 0632053844

Harris, D C. (2010). *Quantitative Chemical Analysis* 8th ed.
W.H. Freeman and Co., ISBN 9781429239899

Douglas A. Skoog, Donald M. West, James Holler, Stanley R. Crouch (2014). Fundamentals of Analytical Chemistry, 9th Edition, ISBN-13: 9780495558286

Douglas A. Skoog, Donald M. West, James Holler, Stanley R. Crouch (2000).Analytical Chemistry: An Introduction, 7th Edition, ISBN-13: 9780030202933

9.3 Optional Materials

Ellison, S. L. R. et al. (2009) Practical statistics for the analytical scientist: a bench guide. RSC Publishing. ISBN 9780854041312

Willard, Merritt, Dean, Settle (2016) Instrumental Methods of Analysis, 7th edition, (ISBN 0534081428)
8th edition, (ISBN-13: 978-0471713968, ISBN-10: 0471713961)

Francis Rouessac & Annick Rouessac. Chemical Analysis: Modern Instrumentation Methods and Techniques", 2nd edition.

James W. Robinson, Eileen M. Skelly Frame, George M. Frame II. Undergraduate Instrumental Analysis, 7th Edition.

Davis R. (1987), *Mass spectrometry*.

Evans A. (1987), *Potentiometry and ion selective electrodes.*

Geary W.J. (1986), *Radiochemical methods.*

George B. and McIntyre P. (1987), *Infrared spectroscopy.*

Hamilton R. and Hamilton S. (1987), *Thin layer chromatography.*

Hawcroft D. and Hector T. (1987), *Clinical specimens.*

Lindsay S. (1992), *High performance liquid chromatography.*

Melvin M. (1987), *Electrophoresis.*

Metcalfe E. (1987), *Atomic absorption and emission spectroscopy.*

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Rendell D. (1987), *Fluorescence and phosphorescence spectroscopy.*

Rowell F. and Hector T. (1988), *Quantitative bioassay.*

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Woodget B. (1987), *Samples and standards.*

Analytical Chemistry by Open Learning, John Wiley & Son.

Continued….

9.4 Notes

Plagiarism

Answers should be in your own words and large sections of published material should not be used either with or without acknowledgement. Diagrams from such sources may be used if acknowledged however.

All diagrams and direct quotations from published or internet sources should be given a numbered reference.

You are reminded that the range of penalties that may be imposed are:

a) oral or written warning recorded on the student file;
b) reduced mark for the element of assessment;
c) capping at the pass mark a module for which a higher mark would otherwise have been given;
d) failure in the module with the opportunity to be referred if the regulations otherwise permit this;
e) failure in the module without opportunity to be referred, but with the possibility of repeat assessment or assessment of an alternative module in the next academic year or at a later date if the regulations otherwise permit;
f) failure in the module without the opportunity to be reassessed or to take an alternative module.
g) failure in all modules in a year or semester;
h) a recommendation to the Deputy Vice-Chancellor that the student's studies be terminated.

NOTE: YOUR OVERALL MARK IS LINKED TO YOUR ATTENDANCE – SEE THE INSTRUCTIONS ON PAGE 18.

10. STANDARD FORMAT FOR LABORATORY REPORTS

Standard format for reports should be Arial font, size 12, paragraphs 1.5 spacing and fully justified. Reports should use Harvard referencing system

There are important guidelines that you should follow in all forms of scientific writing to ensure success in this endeavour:

- Write in the past tense
- Avoid the use of 'I' or 'We'. Write in the passive voice.
- Always reference your source material fully in bibliographic format.
- Use SI units only. Do not forget the units but be aware that some values (e.g. absorbance) are dimensionless, i.e. have no units, so do not give values units that they do not have. If you manipulate a value mathematically (e.g. take a reciprocal) then the same manipulation must be applied to the units.
- No value means anything without the correct units!
- Species names should be given in full, written in italics e.g. *Homo sapiens, Eschericia coli* at first but subsequently the Genus name can be abbreviated (*E. coli*)
- Chemical names should be written in full, together with the chemical symbol, the first time they are used e.g. sulphuric acid (H_2SO_4). However IUPAC names for common compounds are not mandatory: acetone is as acceptable as propanone
- Define any non-standard abbreviations at first use.. Some very common biochemical abbreviations are, for example, standard and need not be defined in the main text (DNA, RNA, ATP, NADH, etc.).
- **DO NOT** copy detailed methods or other content directly from practical schedules. **ALL** work must be your own. Otherwise you accomplish very little.
- Keep sentences short. This helps to avoid ambiguity. The shorter the sentence the simpler it is and so it is easier to understand.

Look at papers published in scientific journals (browse on Science Direct, available via the Library catalogue) to see how your report should be written. Journals vary slightly in how they format articles but most follow a similar format.

The standard format for a scientific report is as follows:

- Title
- Abstract
- Introduction
- Methods
- Results
- Discussion
- Conclusions
- References
- Appendices (where appropriate)

Title
The title should be brief and descriptive.

Abstract (5%)
The abstract should be a short (no more than 200 words) summary of the essential information from the report. It should set out the background, aims methods results and conclusions. The results and conclusions are the most important part of the abstract. References are *not* cited in the Abstract.

Introduction (25%)
The introduction should describe the background and aims of the investigation. It should be introduce the work to be presented and not be a free-standing essay on the topic. It should clearly answer the following questions:

- What has been done before?
- What still needs to be investigated?
- Why is the work important?
- What are the aims of the investigation?

Methods (15%)
The method section should describe:

- What was done
- How it was done
- What equipment was used
- What statistical tests, if any, were used.
- Record of calibration / standard dilutions
- Calculations

If you have been working from a detailed practical schedule, do not copy the method but describe any changes that you made. You do not need to list every item or material used but you should record the details of any analytical instrumentation used – make, model and operating parameters and any reagents used .
You **do not** need to present photographs/diagrams of standard items of laboratory equipment.

Results (20%)
The results section should describe, in a commentary, what was found, using tables and figures to demonstrate your findings. Data appearing in a table should not also appear in a figure (or *vice* versa). You should also include the results of any statistical analysis.

DO NOT interpret or explain the results in this section. In the results you describe, in the discussion you discuss (obviously). This distinction can be rather subtle, but it is important.

Guide your reader through the key features of the results and what is demonstrated by each table or figure. DO NOT present a Results section that solely consists of tables and figures. Refer to your tables etc. by number e.g. Table 3, Figure 2

You should include (where appropriate) the following in your results:

- Presumptive test results
- Actual values and calculations of 'Unknown' and recovery concentrations, including observations.
- Statistics eg. % RSD, precision (repeatability), accuracy (reproducibility)
- Every table, graph, photograph or diagram should be clearly numbered, in sequence, and have a clear descriptive heading. You should add a short description under the heading (the *figure legend*)
- Each table (including title) should fit on one page.
- Each column in a table must have a clear heading, including units of measurement. Never forget the units.
- All graphs should be drawn using MS Excel (or equivalent software) – ensure you use the correct graph type for your data!
- Avoid the use of colour in your figures. Do not use background fill or gridlines.
- Graphs should be large enough for data to be clearly visible.
- Variables must be plotted on the correct axis. The control parameter (what you vary) is on the x-axis and the observed parameter (what you see as a result of the variation) is on the y axis.
- Axes must be clearly and correctly labelled and units shown.
- Use scientific notation in the axis label to remove leading or trailing zeroes on the axis values or select the appropriate number of significant places.
- It is not always necessary to use a true origin. A false origin is acceptable if small changes were observed, for example.
- If appropriate, place different plots on the same graph if this makes differences in the different data sets easier to compare.
- Data points must be clearly shown on the graph.
- Where a regression line is fitted, the equation and R^2 (correlation of determination) value should be shown.
- Where it is requested, give a sample calculation for one result and then simply give the calculated results for all the other results. It is superfluous to give detailed calculations for every single result.
- If you need to write an equation, use the Equation Editor facility in MS Word. If you just use Word itself for this the equations are almost always impossible to interpret.
- Data and results of calculations should be shown to the same number of significant figures as the original measurements.
- Results of statistical analysis should state the name of the test, the test statistic, number of measurements and the level of significance determined (the probability value).

Discussion (25%)

The discussion should interpret and explain the results of the experiment and relate your findings to other published work. It *must* be an extension of the "Results" section, describing the implications and conclusions that follow from your findings. It must *not* be a free-standing essay on the topic. It should also refer back to the aims stated in the "Introduction"

- State your key findings in one or two sentences.
- Discuss each finding in turn, relating to other work, where relevant, and explaining any differences you may have found from published and/or expected results.
- Discuss the implications of your findings, especially those which may be relevant more generally, beyond the confines of the experimental set-up you have used
- Identify areas where you had problems and/or potential sources of error (**DO NOT** simply blame poor results on 'human error', the experiment being 'too difficult' or the equipment used). Think carefully about this; no experimental design is ever perfect and you should be able to comment meaningfully on any shortcomings of the procedure, especially on any implicit assumptions that have been made in the basic design.
- Identify areas for improvement in the experimental design (**DO NOT** claim that automated/computerised apparatus would give better results) and suggest how the investigation might be continued; think carefully, if we had more money and more time how could we have overcome any shortcomings that you identified previously?

Conclusion (5%)

Conclude with a brief paragraph (200 words) summarising the key findings and their interpretation.

References

You should include a complete list of ALL the references that you cited in your text, using the Harvard System of referencing:
(http://www.library.lsbu.ac.uk/helpsheets/hs30.pdf).
References to web sites should include the **full** web address of the actual site used (not links from search engines) and the date and time the site was accessed.

Appendices

Your results section should contain the key data, but this may have been processed from a larger data set that is not included.

You may occasionally wish to include this raw data and/or additional information, such as print-outs from instrumentation, examples of calculations, etc. in your report for reference. Each type of information should be placed in its own numbered and clearly titled appendix.

Presentation, Spelling & Grammar (5%)

General help

If you would like help with general points of style for scientific writing the following site (ignore the second part about Web authoring) at the National Institutes of Health in the US is very informative, especially if your first language is not English:
http://www.ncbi.nlm.nih.gov/bookshelf/br.fcgi?book=styleguide

SI Units: http://www.npl.co.uk/reference/measurement-units/
http://physics.nist.gov/cuu/Units/units.html

See module Moodle sites for details of acceptable standard abbreviations.