BAA Research and Analysis 11

District Name: Abbotsford

District Number: 034

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School Name: Abbotsford Collegiate

Principal's Name: Bill MacGregor

Board/Authority Approval Date:

Board/Authority Signature:

Course Name: Research and Analysis 11

Grade Level of Course: Grade 11

Number of Course Credits: 4

Number of Hours of Instruction: 120

Prerequisite(s): Research and Analysis 10 or M&SP evaluation

Special Training, Facilities or Equipment Required: None

Course Synopsis:

This is a 4-credit course designed to continue the development of the Research and Analysis 10 students in areas applied mathematics, research and analytical skills. This course takes the student to the next level in conducting experimental research and the analysis of more complex data sets. Emphasis will be placed on the design and execution of experiments and computer processing of the results. Students will be introduced to data processing by writing their own computer programs in C or C++ and by performing elementary statistical analysis using math packages. By this stage, students will be skilled at manual data processing and graphing methods. Independent reasoning and math application will be stressed. Data analysis will include the drawing of conclusions from experimental data and critiquing the methods used to acquire the data. Students will be expected to make more formal written and or presentations of research results and/or the results of assigned analytical tasks. RA 11 students will be

expected to serve as mentors for junior students. Formal presentation of results will take place with an audience composed of persons not involved in the course, e.g., other students, other teachers, parents, invited guests.

Rationale:

The development of scientific skills is a longitudinal process that is accomplished over many years. The Math and Science Program at Abbotsford Collegiate is intended to give qualifying students an opportunity to graduate from high school with skill levels in the applications of mathematics, logical deduction, design and implementation of experiments and scientific oral and written presentation that transcends that of any secondary school in British Columbia. This course, Research and Analysis 11, builds on the progress made in Research and Analysis 9 and 10, and stresses the integration of mathematical analysis and reasoning as a fundamental ability in the conduction of scientific research.

Organizational Structure:

Unit/Topic	Title	Time
Unit 1	Laboratory Skills	20
Unit 2	Data Analysis	20
Unit 3	Scientific Communication	15
Unit 4	Computer Programming	25
Unit 5	Experimental Research	40
	Total Hours	120

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Unit/Topic/Module Descriptions:

Unit 1: Laboratory Skills (20 h)

Overview:

The purpose of this unit is to provide the student with basis skills in the operation of laboratory equipment and the collection of data using mechanical, electronic and optical means. The student will learn to use instrumentation such as photogates, lasers, optical components, oscilloscopes, signal generators, power supplies and data collection interfaces to PCs. Laboratory work will involve build simple electrical circuits for implementing data collection such as photocells or controlling solenoids, etc. The emphasis will be on using the various tools in a problem-solving context regarding the efficacy of data collection. The student will take measurements and analyze the data to identify bias, scatter and other features of data that require elimination or minimization. The student, either independently or in group work, will routinely will be required to identify several methods of acquiring data and to identify the method or methods which are best, simplest and most likely to work. In some laboratory exercises the student will be required to collect data by several techniques and to compare the results and assess the appropriateness of each technique.

Curriculum Organizers and Learning Outcomes:

It is expected that the student will be able to:

- Carry out assigned laboratory tasks in an independent manner
- Acquire requisite skills in the connecting together and operation of a variety of pieces of laboratory equipment
- Distinguish between data collection methods in terms of effectiveness, ease of implementation
- Identify elements of data collection techniques will result in data artifacts
- Implement analysis of data sets acquired in laboratory exercises using techniques learned in Unit 2 below
- Work cooperatively in small groups to carry out laboratory tasks
- Demonstrate willingness to accept criticism of data collection techniques and to implement suggestions
- Compare the results of different data collection techniques and identify strengths and weakness

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Unit 2: Data Analysis (20 h)

Overview:

The purpose of this unit is to expand upon the student's ability to process data for the purpose of analysis and decision making. Techniques will be introduced for exploratory data analysis including graphing, scatterplots, detecting outliers and anomalies and discovering underlying trends. Exercises will be introduced which will involve the non-linear plotting of data, mathematical transformations to enhance trends and techniques of data visualization including elementary statistics. Many of the exercises will be group projects to encourage learning by interaction and discussion. Math tools such as Maple and MathLab will be used for this purpose. By increasing the intellectual involvement of students with the data and the mathematical tools, the analytical and reasoning abilities of the students will be considerably enhanced.

Curriculum Organizers and Learning Outcomes:

It is expected that the student will be able to:

- Implement a variety of graphical data analysis techniques such as linearization, scatterplots, logarithmic plotting, sinusoidal plotting etc.
- Implement a variety of data reduction techniques such as mean and standard deviation, least-squares fitting to linear and polynomial functions and data smoothing
- Demonstrate the ability to display data trends in a variety of ways including 3-D plots, histograms and log-log plots
- Perform elementary statistical analysis such as t-tests
- Identify trends, scatter and outliers in data sets
- Demonstrate proficiency in the use of mathematical processing packages such as Maple and/or MathLab
- Work cooperatively in a small group to carry out data analysis projects
- Demonstrate independence in the ability to perform analysis on data sets
- Draw inferences and conclusions as a result of the analysis of data sets
- Present the results of data analysis using the techniques learned in Unit 3 below

Unit 3: Scientific Communication (15 h)

Overview:

The purpose of this unit is to launch the student onto a path which will produce a graduate who is scientifically and linguistically competent. Students will be required to read a variety of materials from scientific literature and attend regular (bi-weekly) seminars. In the seminars, the student will be asked to conduct oral

and written critiques of the scientific ideas contained therein. Each student/group will be required to make regular informal presentations on results of their exercises and/or research. Each student will be required to make one formal oral presentation during the course (on a topic of the student's choosing). The presentations will require preparation of scientific illustrations and the production of a polished PowerPoint presentation. Evaluation will be based on the degree to which the student actively participates as well as formal marking of oral and written presentations.

Curriculum Organizers and Learning Outcomes:

It is expected that the student will be able to:

- Read and critique a variety of scientific materials such as historical documents, scientific papers, excerpts from textbooks and material from websites
- Discuss the role of data, inference and theory-making in the context of scientific investigation
- Differentiate between inductive and deductive reasoning
- Participate in discussions during seminars
- Effectively prepare graphical and written presentations using PowerPoint
- Present cogent and coherent analysis/critiques of materials given for study
- Demonstrate on an on-going basis an increasing repertoire of scientific words and concepts
- Demonstrate a willingness to accept constructive criticism with regard to oral and written contributions

Unit 4: Computer Programming (25 h)

Overview:

The purpose of this unit is to have students learn the rudiments of what is one of the key tools of modern scientific research: computer programming. Through the use of mathematical tools such as MathLab and Maple, students will be introduced to the tools which are in wide use in university and industrial research labs. Actual computer programming in C or C++ will be introduced and students will be expected to process data by implementing their own algorithms to collect and/or and process data obtained from a computer interface to a PC. Students will work in small groups on a larger programming exercise in order to learn the importance of cooperative software design and testing.

Curriculum Organizers and Learning Outcomes:

It is expected that the student will be able to:

- Demonstrate an ability to implement procedures and functions in Maple and/or MathLab
- Demonstrate an ability to implement from scratch a small program written in C/C++
- Implement assigned data processing algorithms in the specified computing environment
- Learn the basics of computer programming in C/C++, including data structures, input/output methods, condition branching statements, loop structures and overall program design
- Demonstrate an ability to use computer programming to process data (e.g., implementing correlation, high-pass filtering, smoothing)
- Implement a program which interfaces to preprogrammed functions (such as contained in *Numerical Recipes in C*
- Demonstrate an ability to work in a team and to show the required stamina/diligence to carry out a programming task from beginning to end
- Demonstrate that given programming efforts produce the desired behavior through structured testing

Unit 5: Experimental Research (40 h)

Overview:

The purpose of this unit is to allow the student to design and implement laboratory experiments which implement a design-test-redesign cycle. Students will be required to take an assigned topic and research approaches to a solution. The research will involve construction of apparatus, testing and redesign of one or more components before data acquisition can begin. The students will maintain professional-quality laboratory notebooks, and will conduct periodic reports into the progress of the experiment. The research will focus on problem solving with a view to testing different approaches and to optimizing accuracy. Students will be expected to produce a formal paper describing the results of their research and to make a formal presentation to the public (parents, teachers and fellow students).

Curriculum Organizers and Learning Outcomes:

It is expected that the student will be able to:

- Demonstrate the ability to maintain a professional laboratory notebook
- Identify and implement an experimental approach to attain a desired research end
- Identify the basic hypothesis associated with the research project(s)
- Carry out research activities over a period of weeks to months
- Show flexibility in the determining the timing of research activities
- Build required components of the research apparatus

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- Integrate electronic, mechanical or optical devices as part of the apparatus
- Collect and analyze data on an on-going basis
- Identify weaknesses in the experimental approach through analysis and testing
- Implement a design-build-test-design cycle in the pursuit of a research goal
- Identify likely difficulties and outcomes associated with specific research tasks
- Demonstrate independence of thought and action in a laboratory research context
- Demonstrate the ability to carry out research tasks in a small group

Instructional Component:

- **Direct instruction**
- **Laboratory demonstration**
- **Mentoring of junior students**
- **Seminars**
- **Workshops**
- **Independent research**
- **Literature research**
- **Group work**
- **Individual presentation**
- **Teacher observation and assessment**
- **Self-evaluation**
- **Group/peer evaluation**
- **Guest speakers from academia and industry**

Assessment Component:

40% on laboratory exercises and written assignments
20% on presentations (oral and written)
15% on formal laboratory skills tests
20% on summative testing (final exam including laboratory exam)
5% on maintenance of laboratory notebooks

Learning Resources:

- Internet (with instructor-qualified websites), e.g.,
  on-line tutorials in C programming (many available)
  articles in on-line journals (many available free) for discussion
- Excerpts from scientific papers
- Individually researched scientific papers

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- Textbooks, e.g.,
  D. Moore, Basic Practice of Statistics
  MLA Handbook for Writers of Research Papers
  Introduction to MatLab for Engineers and Scientists
  P. Bergman, How to Control the World with your PC
  The Essentials of Numerical Analysis
  Maple and MatLab Manuals
- On-line computer help
- Planned and supervised visits to UCFV library
- Science journals such as Scientific American, Physics Today, Psychology.
- Instructor-provided materials
- Reading-room materials

Additional Information:

Research and Analysis is the backbone of the Mathematics and Science Program at Abbotsford Collegiate. It is designed as a magnet program that will attract students both locally, the lower mainland and abroad. Students will be selected for the program on the basis of the following characteristics:

- demonstrated aptitude for mathematics and science (not necessarily top-student category)
- demonstrated diligence for and interest in problem-solving
- genuine interest in pursuing a career in science
- desire to learn the "art" of research before leaving high school
- willingness to give what is required to produce the end result

The selection process will involve application, teacher recommendation, personal interview and a qualifying exam. The application will consist of a multi-page booklet which will provide the prospective student with insight into the Mathematics & Science Program and simultaneously provide AC with a view to the likelihood of success of the student in the program.

The basic model is that of a sports team: instruction specific to an end, individual mentoring and guidance, mentoring of junior students by senior students, personal dedication to a goal and willingness to strive individually and collectively to achieve an end result.