BAA Research and Analysis 10 Framework

District Name: Abbotsford

District Number: 034

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Date Developed: January 5, 2006

School Name: Abbotsford Collegiate

Principal's Name: Bill MacGregor

Board/Authority Approval Date:

Board/Authority Signature:

Course Name: Research and Analysis 10

Grade Level of Course: Grade 10

Number of Course Credits: 4

Number of Hours of Instruction: 120

Prerequisite(s): Research and Analysis 9 or M&SP evaluation

Special Training, Facilities or Equipment Required: None

Course Synopsis:

This is a 4-credit course designed for students who have completed Research and Analysis 9 in the Mathematics and Science Program at Abbotsford Collegiate. New entrants may also take the course if they are deemed to have equivalent backgrounds from other programs or schools. The focus of this course is to continue the development of the grade 9 students' applied mathematical, research and analytical skills.

Research and Analysis 10 takes the student to the next level in conducting research and analyzing the results. Emphasis will be placed on the design of experiments and the mathematics of data analysis including advanced techniques such as data linearization and least squares fitting. In addition, students will be introduced to computerized processing of data and computer programming using mathematical packages such as Maple and/or MathLab.

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Independence of thought and action will be the key elements of laboratory experience in this course. Students will be expected to maintain professional laboratory notebooks and will make periodic oral and written presentations of their work. Students will be introduced to a variety of laboratory and analytical skills which are not typically learned until later high school or possibly even university. Students are expected to show enthusiasm for laboratory work and diligence in carrying it out. RA 10 students will be expected to spend a portion of their time mentoring RA 9 students.

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 10, builds on the progress made in Research and Analysis 9, and stresses independence of thought and work ethic that is a fundamental characteristic of a scientist.

Organizational Structure:

Unit/Topic	Title	Time
Unit 1	Laboratory Skills	25
Unit 2	Data Analysis	20
Unit 3	Scientific Communication	15
Unit 4	Applied Geometry	15
Unit 5	Theory of Science	15
Unit 6	Experimental Research	30
	Total Hours	120

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Unit/Topic/Module Descriptions:

Unit 1: Laboratory Skills (25 h)

Overview:

The purpose of this unit is to provide the student with basis skills in the operation of laboratory equipment. Included in the unit will be reading of mechanical scales, error analysis, operation of equipment such as balances, photogates, oscilloscopes, etc. Students will also have the opportunity to learn manual skills by building their own devices to accomplish defined tasks during experiments.

Curriculum Organizers and Learning Outcomes:

It is expected that the student will be able to:

- Read to appropriate levels of accuracy any mechanical or electronic scales available
- Analyze data collection methods from the perspective of accuracy and reproducibility
- Identify contributions to uncertainty in a variety of data-collection techniques
- Assemble and test equipment to perform assigned measurement tasks
- Plot raw data obtained from measurements for the purpose of identifying the accuracy of the data-collection process
- Use laboratory equipment in an appropriate manner for the purposes of taking measurements
- Demonstrate manual and reasoning skills with regard to the implementation of data collection techniques
- Demonstrate the ability to respond to constructive criticism with respect to laboratory skills
- Demonstrate stamina, patience and diligence with respect to laboratory work

Unit 2: Data Analysis (20 h)

Overview:

The purpose of this unit is to introduce the student to the concept that scientific principles can be extracted from measured data and that the conclusions can be affected by the methods used. The emphasis will be on the analysis of data collected from a variety of sources such as the scientific literature and the student's own laboratory exercises. Students will use mathematical packages such as Maple and/or MathLab to aid their analysis. Analytical techniques such as least squares curve-fitting will be introduced. Specific topics will address the

issues of random and systematic errors and how they can be identified graphically and analytically. By integrating the analysis of data with math, the student will eventually learn that mathematics is an intrinsic tool of science and will eventually form an intellectual platform upon which all further analysis will be based.

Curriculum Organizers and Learning Outcomes:

It is expected that the student will be able to:

- Plot linear data sets and extract slope/intercept information without instructor assistance or intervention
- Extract algebraic equations from linear data
- Perform least-squares fit analysis using Maple/MathLab
- Analysis data with statistical relationships using scatterplots and correlations
- Plot histograms and extract means and standard deviations
- Identify data trends by graphical and analytic techniques
- Relate uncertainty to scatter in data
- Identify systematic and random errors in data
- Identify data events from plots of data
- Sketch graphs of data from hypothetical situations
- Distinguish between raw data plots and processed data plots
- Manually extract parameters from data using linearization techniques

Unit 3: Scientific Communication (15 h)

Overview:

The purpose of this unit is advance the scientific and general literacy of the student. Specific instruction will be provided in the structure of scientific reports and scientific papers. Specific scientific vocabulary will be introduced and the students will be expected to use the vocabulary in other exercises. The exercises in this unit will be based on written and oral presentation, including the preparation of scientific illustrations. Students will be required to read a variety of materials from scientific literature and provide oral and written analysis of the reading materials. Students will be required to attend seminars in which the contents of the materials are discussed. Students will be expected to demonstrate their ability to comprehend and analyze the reading materials by providing summaries and analyses during seminars. Each student will be required to make informal and semi-formal (i.e., prepared) presentations on selected topics. The student will be required to write one scientific report for this unit plus other reports as required in the other units. Evaluation will be based on the degree to which the student actively participates as well as formal marking of oral and written presentations.

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Curriculum Organizers and Learning Outcomes:

It is expected that the student will be able to:

- Write one or more scientific reports according to the structure given
- Demonstrate a willingness to accept constructive criticism in written and oral presentation
- Present material to the rest of the class during seminars
- Design and implement a variety of scientific illustrations including graphs, charts, two-dimensional equipment diagrams and elementary three-dimensional diagrams
- Use PowerPoint to aid presentations of ideas
- Participate in round-table discussions of ideas presented in scientific readings
- Analyze and critique various scientific readings and idea
- Argue a point of view using valid arguing techniques

Unit 4: Applied Geometry (15 h)

Overview:

The purpose of this unit is to explicitly strengthen the ability of students to attack problems from a geometrical point of view. This unit will expose students to underlying geometries of real and abstract problems through instruction, group work and hands-on laboratory situations. Problems will be presented which involve the use two-dimensional and three-dimension geometry, including spherical geometry. The emphasis will be on the use of geometry, not on its abstract principles.

Curriculum Organizers and Learning Outcomes:

It is expected that the student will be able to:

- Solve a variety of physical problems in which geometry plays a fundamental role
- Apply formulas for perimeter, area and volume to simple and compound objects
- Solve elementary problems in optics using principles of geometry
- Plot sine and cosine functions
- Use trigonometric functions to solve real-world problems (e.g., optics, mechanical systems, astronomical problems)
- Integrate algebraic principles with geometrical analysis
- Evaluation will consist of assignments an a unit exam in applied geometry

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Unit 5: Theory of Science (15 h)

Overview:

The purpose of this unit is to lay the foundations for the theory of science and theory-building. The ideas of questions and answers, cause and effect, knowable and unknowable, limited and limitless and other concepts which are affected by the interpretation and validity of measurements will be discussed. Students will learn about and discuss ideas about truth, relative truth, uncertainty, hypotheses, theories and models. The role of data acquisition and interpretation, measuring the invisible and unreachable and direct vs. indirect measurement will be discussed an implemented in student exercises. The concept of model, theory and scientific law will serve as the principle structure around which discussions are based. Principles such as Ockham's Razor, Ramsay's Theorem and Murphy's Law will be included. Students will be given problems in theory-making to implement the ideas in this Unit. This unit will be a continuation of Theory of Science in Research and Analysis 9.

Curriculum Organizers and Learning Outcomes:

It is expected that the student will be able to:

- Participate actively in discussions based on assigned readings
- Summarize and analyze arguments presented as written materials or during group discussions
- Demonstrate an understanding of inductive and deductive reasoning
- Relate the role of equipment characteristics in data acquisition, especially concerning control of extraneous variables
- Relate the role of prior data in the formation of hypotheses
- Propose theories to account for observed facts (using a variety of student exercises)
- Revise theories when additional facts are encountered
- Criticize shortcomings of theories presented to explain facts
- Appreciate the role that data have in the selection of competing theories
- Appreciate the fact that science is necessarily in a state of flux and that theory-making is an on-going rather than end in itself

Unit 6: Experimental Research (30 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:

- Maintain a laboratory notebook to professional standards
- Assemble/build simple laboratory equipment for the purposes of performing data acquisition
- Take measurements with due consideration to systematic and random error
- Identify sources of error and estimate magnitudes of errors in data collection
- Build/implement scientific apparatus using a design-implement-test-redesign cycle
- Justify the method of data collection chosen
- Develop an awareness to controlling extraneous variables during data collection
- Work cooperatively in a small group to accomplish an assigned task
- Demonstrate stamina and diligence in scientific research work
- Analyze data on an on-going basis
- Provide daily/weekly progress reports on an informal and formal basis
- Present the results of research formally (both orally and written as a short scientific paper)

Instructional Component:

- **Direct instruction**
- **Mentoring by senior students**
- **Laboratory demonstration**
- **Seminars**
- **Specialized workshops**
- **Independent research**
- **Literature research**
- **Group work**
- **Individual presentation**
- **Teacher observation and assessment**
- **Self-evaluation**

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- **Group/peer interaction and mentoring**
- **Mentoring by senior students**
- **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 plus laboratory exam)
5% on maintenance of laboratory notebooks

Learning Resources:

- Internet (with instructor-qualified websites), e.g.,
  On-line Technical Writing textbook:
  http://www.io.com/~hcexres/tcm1603/acchtml/acctoc.html
  Writing Lab reports:
  http://www.learningcommons.uoguelph.ca/ByTopic/Writing/WritingAssignments/Fastfacts-WritingLabReports.html
  Theory/model-building:
  http://acept.la.asu.edu/courses/phs110/si/chapter1/main.html
  http://www.helsinki.fi/science/networkedlearning/eng/delete.html
  Science for All Americans On-Line
  http://www.project2061.org/publications/sfaa/online/sfaatoc.htm?txtRef=http%3A%2F%2Ffalcon%2Ejmu%2Eedu%2F%7Eramseyil%2Fmath%2Ehtm&txtURIOld=%2Ftools%2Fsfaaol%2Fsfaatoc%2Ehtm
- Selected excerpts from scientific papers
- Individually research scientific papers and web-based articles
- Textbooks (note: there is no one textbook that covers the topics in this course), e.g.,
  J. Holland, Hidden Order: How Adaptation Builds Complexity
  Learn MatLab 5 in 6 Hours

- Planned and supervised visits to UCFV library
- Science journals such as New Scientist, Scientific American, Physics Today, Psychology.
- Instructor-provided materials
- Reading-room materials

Additional Information:

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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 and will follow criteria that will entice students who have

- Above-average intelligence (though not necessarily exceptional intelligence)
- A genuine interest in pursuing a career in science
- A desire to become learn the "art" of research before leaving high school
- A willingness to give what is required to produce the end result

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.