ORANGE HIGH SCHOOL

ORANGE

NEW JERSEY

Course Curriculum for Experimental Science 1 Electrochemistry. Batteries

Grade Levels 10-12

I. Course Description

1. General goals of the course

The overall goal of the Experimental Science Program is to enable a student to learn how chemist, engineers and other scientists work as researchers. Student will acquire knowledge and develop understanding through experimental research. Students will learn how to devise and define research questions and hypotheses, how to acquire and analyze data, and how to report results orally and in writing. This knowledge will be acquired by mastery of the five phases of a research project. These are: 1) Introductory; 2) Methods; 3); Results, 4) Discussion, and 5) Presentation.

In each phase, there are procedures that must be learned and applied.

1) The **Introductory phase** includes:
   a) Making an observation
   b) Formulating a research question
   c) Why is this interesting question worthy of study?
   d) Gathering background information
   e) Comparing known facts with the observation: Is there still a question?
   f) Reformulating research question (if needed)
   g) Constructing an explanatory hypothesis (a tentative answer)

2) The **Methods phase** includes:
   a) Creating a research investigation design
   b) Identifying the subject, number and source
   c) Obtaining equipment and supplies
   d) Defining a procedure for the experiment

3) The **Results phase** includes:
   a) Collecting qualitative and quantitative data
   b) Organizing and summarizing the data
   c) Analyzing the data

4) The **Discussion phase** includes:
   a) Restating the main findings
   b) Restating the hypothesis
   c) Discussing whether the results do or do not support the hypothesis
   d) Discussing how the results compare to findings from previous studies
   e) Stating the conclusions
   f) Suggesting future research

5) The **Presentation phase**, encompassing phases 1-4, includes:
   a) Writing a research paper
   b) Writing an abstract
   c) Preparing an oral presentation

d) Preparing a poster presentation

Each item in every phase requires training, for which there is an obligatory order in some cases. For example, an experiment cannot be designed **(2A)** until the student has an understanding of statistical analysis **(3C).** Thus, the optimal strategy for teaching the process does not reflect the progression of the process during an actual scientific investigation. The student should be trained in data analysis BEFORE he or she begins working on a research project.

With the assistance of the instructor, students will have developed a plan for an independent research in **Experimental Science I**, which will be initiated in **Research 1**, which should be taken simultaneously with **Experimental Science 2.**

2. Overview of student activities in the course

Experimental Science I is an elective course for students who have completed basic chemistry. It is intended primarily for those students seeking to compete in science project and scholarship competitions, but would be a useful course for any student that wants to improve their capacity to think logically and to come to rational decisions based on an evaluation of available information. This course meets approximately 2 hours per week. The overall focus of the course is to developed an understanding of how to think experimentally; in other words, how to identify feasible and meaningful research topics, how to formulate hypotheses, how to identify and prevent spurious and artifactual conclusions, and how scientific results are communicated. This course explores communication topics in verbal, written, and visual modes, including oral presentation preparation and delivery, research paper organization and writing, and science poster design and construction. The use of statistics to design and support experiments will be strongly emphasized. Examples from the literature will be used to demonstrate the successes and abuses of the scientific review and publication process.
In addition, data generated by students will be used as examples for the class with regard to development of the research, analysis of the data, scientific writing and presentation.

The students will continue their exploration of the scientific literature, learning about the structure of a scientific paper (and by extension, a scientific project), optimal presentation of the data, and the review process leading to acceptance and publication (or rejection) of the paper. Students will write a paper which will be critiqued by a review panel of peers (other students). Examples from the literature will be used to demonstrate the successes and abuses of the scientific review and publication process.

3. Highlighted unit topics

The course of study includes:

Unit 1. Introduction to the Scientific Literature and Review Process
Unit 2. Model Systems in Electrochemical-Battery Research
Unit 3. The Individualized Research Project
Unit 4. Reporting and Presenting the Data.

4. General teaching philosophy

Experimental Science is the lab course with lecture components. The majority of the work will involve a hands-on approach. This will involve physical measurements or followed by tabulation and analysis of the data.
Cooperative learning will be emphasized, but the students will be encouraged to develop individual research projects based on their personal interests, with the guidance of the instructor. The general format of the one-hour class periods will be as follows: Approximately 15-20 minutes to go over readings, questions and lab procedures, followed by 30 minutes of lab work, and finishing up with 10-15 minutes of discussion and suggested approaches to analysis. Much of the analytical work will be performed outside the lab, as assigned homework.

In order to understand the concepts behind the labs that they will be performing and to develop their ideas into research hypotheses, students will be expected to do a considerable amount of outside reading. Only students strongly motivated to do research will find this acceptable, but it closely mirrors the situation they will discover in any real-world situation, including research internships, and it is important for students to learn early in their careers whether they are suited for this type of work.

There is a unit structure to this course. Labs are planned with the goal of developing a sense of forming research questions, analyzing data, and rational experimental design. These principles will be applied to the individualized research projects.

II. Course Objectives

Upon the successful completion of this course the student will be able to:

A. Analyze science research information through databases, literature and the internet

B. Draw technical images for science reports and papers

C. Draw, scan and edit images for presentations

D. Demonstrate an understanding of the scientific method by:
   1. **formulating** a hypothesis
   2. **designing** an experimental protocol
   3. **organizing** data in a spreadsheet
   4. **analyzing** data using a statistics program
   5. **summarizing** data using tables and graphs
   6. **discussing** the results
   7. **writing** an abstract that summarizes a scientific report

E. Present a scientific study via a science fair-quality poster

F. Organize and give a computer slide (Powerpoint) presentation

G. Participate in a high-value individualized research project

H. Understand and apply the principles of scientific writing and the review process for scientific publications

During the lab periods concerns include safety, accurate measurement, and the recording of data. Students will be expected to do assign outside readings to prepare for the classroom and lab work. They will need to understand the concepts behind the labs that they will be performing. In addition, some of the analysis work must be done outside of class.

In the second part, students will enroll in **Experimental Science 2**. The focus of **ExpSci2** will be the development of a high quality scientific article based on the data obtained in Research 1, and employing the principles of data analysis and criticism begun in **ExpSci1**. Students may work in groups if their projects share sufficient overlap to represent a valid scientific model. Although not required, projects with sufficiently interesting and novel results may be submitted to scientific journals for potential publication.

Course Objectives
-When making decisions, evaluate conclusions, weigh evidence, and recognize that arguments may not have equal merit. -Assess the risks and benefits associated with alternative solutions. -Engage in collaboration, peer review, and accurate reporting of findings. -Explore cases that demonstrate the interdisciplinary nature of the scientific enterprise. - Select and use appropriate instrumentation to design and conduct investigations. - Show that experimental results can lead to new questions and further investigations - Understand, evaluate and practice safe procedures for conducting science investigations - Recognize the role of the scientific community in responding to changing social and political conditions and how scientific and technological achievement effect historical events . - Examine the lives and contributions of important scientists who effected major breakthroughs in our understanding of the natural and designed world. -Discuss significant technological achievements in which science has played an important part as well as - technological advances that have contributed directly to the advancement of scientific knowledge. - Describe the historical origin of important scientific developments such as atomic theory, genetics, plate tectonics, etc., showing how scientific theories develop, are tested, and can be replaced or modified in light of new information and improved investigative techniques. - When performing mathematical operations with measured quantities, express answers to reflect the degree of precision and accuracy of the input data. - Apply mathematical models that describe physical phenomena to predict real world events.

- Construct and interpret graphs of data to represent inverse and non-linear relationships, and statistical distributions.

- Know that scientific inquiry is driven by the desire to understand the natural world and seeks to answer questions that may or may not directly influence humans, while technology is driven by the need to meet human needs and solve human problems.

- Assess the impacts of introducing a new technology in terms of alternative solutions, costs, tradeoffs, risks, benefits environmental impact.

- Plan, develop, and implement a proposal to solve an authentic, technological problem.

-Show that in most chemical reactions energy is transferred into or out of a system.
- Explain that atoms form bonds (ionic and covalent) with other atoms by transferring or sharing electrons.

-Create a multi-page document with citations using word processing software in conjunction with other tools that demonstrates the ability to format, edit, and print.
- Construct a spreadsheet, enter data, use mathematical or logical functions to manipulate and process data, generate charts and graphs, and interpret the results.
- Produce a multimedia project using text, graphics, moving images, and sound.
- Produce and edit page layouts in different formats using desktop publishing and graphics software.
- Merge information from one document to another.

- Describe the potential and implications of contemporary and emerging computer applications for personal, social, lifelong learning, and workplace needs.
- Exhibit legal and ethical behaviors when using information and technology, and discuss consequences of misuse.
- Make informed choices among technology systems, resources, and services in a variety of contexts.
- Use appropriate language when communicating with diverse audiences using computer and information literacy.
- Select and use specialized databases for advanced research to solve real world problems.
- Evaluate information sources for accuracy, relevance, and appropriateness.
- Create and manipulate information, independently and/or collaboratively, to solve problems and design and develop products

- Use appropriate data to discuss the full costs, benefits and trade-offs, and risks related to the use of technologies.
- Provide various examples of how technological developments have shaped human history

- Analyze a given technological product, system, or environment to understand how the engineering design process and design specification limitations influenced the final solution.
- Develop methods for creating possible solutions, modeling and testing solutions, and modifying proposed design in the solution of a technological problem using hands-on activities.

Specific Course Objectives **The student will be able to …**	**NJCCCS** Standard and Strand
Understand the scientific method and the principles on which it is based	5.2A1, 5.2B1, 5.2B2, 5.2B3.

Develop observations into research questions and hypotheses	8.1A3, 5.1A1, 5.1A2, 5.1A3, 5.1B2
Understand what differentiates an experiment from a random collection of data points	5.1B2, 8.1B1, 8.1B2,8.1B3, 8
Understand the concept of “control”	5.4A1, 5.1A1, 5.1A2, 5.1C1
Devise an experiment to test a hypothesis	5.1A1, 5.1B2, 5.1C1, 5.4C1,
Understand the contributions of scientists to the chemical sciences. (the “big ideas” in chemistry)	5.1A2, 5.1B1, 5.1B2, 5.2B3, 8.2A3, 5.4A1, 5.2B3
Understand the difference between theory, hypothesis and law	5.4A1, 8.1B2
Understand the ethical implications of falsifying data	5.4A1, 5.4B1, 5.4C1
Understand the importance of lab safety and instrument calibration.	8.1A1, 8.1A3, 5.1A3, 5.1C1
Understand scientific record keeping	5.1A1, 5.3B1, 5.3D1
Understand the use of statistics and probability in science, including normal data distribution, variance and deviation, and using test and confidence levels to determine significance.	
Collect data, enter it into an excel workbook and analyze it	8.1A3, 8.1A9, 8.1B8
Understand how to “mine” data by grouping	8.1A3, 8.1A9, 8.1B88.1B8, 8 5.3C1, 53D1
Understand the sources of error and bias in experiments	5.1A1, 5.3D1, 8.1A3, 8.1A5,
Understand graphical representation of data	8.1A1, 8.1A3
Understand the structure of a scientific paper and write one	5.2A1, 5.1B2
Understand the review peer review process for scientific paper	8.2B1, 8.1B2, 8.1B3
Participate in a “review panel” to critique papers in class	8.2A1
Be able to access an use scientific databases on the internet	5.4C3, 5.3C1
Understand the concept of “intellectual property”	5.3B1, 5.4C1, 8.1B4, 8.1A
Understand how to design and carry out independent research	8.1A6

Present independent research in class (powerpoint/oral) at a science fair.	

Course Content Outline

Unit 1 – The Scientific Method (3 sessions)

Lesson 1.1 – Logic and flow of the Scientific Method

1.1.1. Introduction to the method
1.1.2. Making an observation
1.1.3. Asking a question based on the observation
1.1.4. Turning the question into a testable hypothesis
1.1.5. Devising an experiment to test the hypothesis

Lesson 1.2 – Using the scientific method

1.2.1 Predicting the outcome of the experiment
1.2.2 Performing the experiment
1.2.3. Analyzing the results
1.2.4 Evaluating the hypothesis
1.2.5. Now what?

Lesson 1.3 – The Great Experiments in Electrochemistry

1.3.1. Application of the Scientific Method to Electrochemistry
1.3.2. Theory, hypothesis and law
1.3.3. Why electrochemistry is difficult to study
1.3.4 Artifacts, guesses and false conclusions

Unit 2 – Data Analysis

Lesson 2.1 – How do we know our results are Real?

2.1.1. Scientific record keeping – the notebook
2.1.2. Taking measurements
2.1.3. Probability and statistics
2.1.4 Data distribution and standard deviation
2.1.5 The Student's t test and confidence

Lesson 2.2 – Experiment 1- Analysis of the human face (part 1)

2.2.1. Measurable parameters and measuring instruments
2.2.2. Learning about excel
2.2.3. Entering and analyzing data
2.2.4. Grouping data – what else can I learn

Lesson 2.3 – Experiment 1- Analysis of the human face (part 2)

2.3.1. Reporting the results
2.2.2 Bias and sources of error
2.3.3 Project documentation and comparison to the literature
2.3.4 What makes this analysis an “experiment”?

Lesson 2.4 – Graphical Analysis of Data

2.4.1. Graphical representation of data
2.4.2. A picture is worth a thousand words…or nothing
2.4.3. How to keep the attention of the audience
2.4.4. Choice of font, color and background

Unit 3. Hypotheses and Rational Experimental Design (3 class periods)

Lesson 3.1 – Developing a Research Plan

3.1.1 Gathering background information
3.1.2 Constructing a hypothesis
3.1.3 Giving credit – citing references and sources

Lesson 3.2 – Study design

3.2.1 The “Subjects” of the study
3.2.2 Random sampling and other techniques
3.2.3 Setting up the “toolkit”
3.2.4 Comparing groups
3.2.5 Types of study design (controlled, blinded, prospective, retrospective, etc.)

Lesson 3.3 – Performing and Reporting the Study

3.3.1. Data Collection
3.3.2. Organizing and presenting data with tables and graphs
3.3.3. What do the data tell us
3.3.4. Writing the Introduction
3.3.5. Writing the Discussion and Conclusions

Unit 4 – Developing an Individualized Research Project

Lesson 4.1 Independent Research Project

4.1.1 Choosing a topic with the instructor
4.1.2 Preparing a work plan
4.1.3 background Information Gathering
4.1.4 Preparing for meetings with the mentor
4.1.4 Preparing the “toolkit”

Unit 5 – Introduction to Scientific Literature and Review

(3 class periods)

Lesson 5.1 Exploring the Databases

5.1.1. How to cite a Database in a publication
5.1.2. STN Express - **http://www.cas.org/support/stnexp/index.html**
5.1.3 SciFinder - **http://www.cas.org/products/sfacad/index.html**
5.1.4. SCOPUS - **http://info.scopus.com/**
5.1.5 USPTO (US patents) - **http://patft.uspto.gov/**
5.1.6 TechOnline - **http://www.techonline.com/**
5.1.7 OSTI – Office of Scientific and Technical Information - **http://www.osti.gov/**
5.1.8 WWW Chemistry Guide - **http://www.chemistryguide.org/**

Lesson 5.2 Exploring and acquiring specific software

5.2.1 ACD/ChemSketch Freeware 12.0. **http://www.acdlabs.com/download/**

Lesson 5.3 You documented your study- now what?

5.3.1 Defining the target audience
5.3.2 Picking a journal
5.3.3 "Instructions to authors"
5.3.4 Protecting your intellectual property

Lesson 5.4 Peer review

5.4.1 The scientific review process
5.4.2 Interpreting the criticism of your research
5.4.3 What do I do next?

Unit 6 – Model Systems in Electrochemistry, Battery Research

(3 class periods)

Lesson 6.1 *Electricity and Batteries*

6.1.1. Historical Background of Electricity
6.1.2 Timeline of Electricity and Batteries
6.1.3 Galvany bioelectricity misconception
6.1.4. Benjamin Franklin experiments

References-Resources: http://www.panasonic.com/environmental/rbrc_lesson_plan.pdf ; Batteries and Energy Storage Craig B. Arnold Department of Mechanical and Aerospace Engineering. http://www.princeton.edu/ssp/workshop/batteries/battery_workshop.pdf

Lesson 6.2 *General Battery Overview*

6.2.1. Electrochemical processes. A Spontaneous Redox Reaction
6.2.2. Voltaic Cells and their Usage as Energy Sources
6.2.3. Rechargeable Batteries.

References-Resources: http://www.panasonic.com/environmental/rbrc_lesson_plan.pdf ;
Prentice Hall Chemistry, A.C. Wilbraham et all. 2005, Pearson;
Handbook of Batteries (3rd Edition). Edited by: Linden, D.; Reddy, T.B. © 2002 McGraw-Hill.
http://www.knovel.com/web/portal/basic_search/display?_EXT_KNOVEL_DISPLAY_bookid=627&_EXT_KNOVEL_DISPLAY_fromSearch=true&_EXT_KNOVEL_DISPLAY_searchType=basic
General Battery Overview. http://www.actcharge.com/literature/brochures/genbattoverview.pdf
http://www.duracell.com/procell/design/default.asp

Lesson 6.3 *Battery and Energy Storage*

6.3.1. Categories of Batteries
6.3.2. Battery Chemistries
6.3.3. Hybrid Batteries
6.3.4. Ultracapacitors
6.3.5. History of battery discovery and development and following innovations.

References-Resources: http://www.panasonic.com/environmental/rbrc_lesson_plan.pdf ;
General Battery Overview. http://www.actcharge.com/literature/brochures/genbattoverview.pdf
Hybrid Batteries Overview. http://www.hybridcars.com/components/hybrid-batteries-overview.html
Battery Types Overview.
http://www.allcelltech.com/./index.php?option=com_content&view=article&id=69&Itemid=80
GREEN ELECTRICITY INITIATIVE. http://www.alexanderbell.us/Initiative/GEL.htm
Ultracapacitors and Hybrid Electric Vehicle. Maxwell Technologies Ultracapacitors
http://images.google.com/imgres?imgurl=http://www.earthtoys.com/articles/05.02.01/maxwell/conten1.gif&imgrefurl=http://www.earthtoys.com/emagazine.php%3Fissue_number%3D05.02.01%26article%3Dmaxwell&usg=__pl5TipBjxKx1xPs2IXcUNQpo4SQ=&h=300&w=470&sz=8&hl=en&start=15&tbnid=mRygRwG68rXLVM:&tbnh=82&tbnw=129&prev=/images%3Fq%3Delectrick%2Benergy%2Bstorage%2Bultracapacitors%26gbv%3D2%26hl%3Den%26sa%3DG
Energy Storage Craig B. Arnold Department of Mechanical and Aerospace Engineering. Video presentation:
http://video.google.com/videosearch?q=+arnold&hl=en&emb=0&aq=f#q=+arnold+batteries&hl=en&emb=0&qvid=+arnold+batteries&vid=-15152228114333857 91&view=2

PowerPoint presentation: three PP presentations attached. Prentice Hall Chemistry, A.C. Wilbraham et all. 2005, Pearson; Presentation Express. Chapter 21.

Unit 7. The Individualized Research Project

Lesson 3.1 Independent Research Project

7.1.1 Refining the topic with the instructor. Lemon Battery
7.1.2 Preparing a work plan
7.1.3 Doing it. Exploration of different natural acids in fruits and vegetables.
7.1.4 Preparing for meetings with the mentor
7.1.4 Preparation of final Work

References-Resources: Lemon Battery Video. http://www.youtube.com/watch?v=AY9qcDCFeVI

Unit 8. Reporting and Presenting the Data

(5 class periods)

Lesson 8.1 Study design

8.1.1 The “Subjects” of the study
8.1.2 Random sampling and other techniques

8.1.3 Setting up the “toolkit”
8.1.4 Comparing groups
8.1.5 Types of study design (controlled, blinded, prospective, retrospective, etc.)

Lesson 8.2 Performing and Reporting the Study
8.2.1 Data Collection
8.2.2 Organizing and presenting data with tables and graphs
8.2.3 What do the data tell us
8.2.4 Writing the Introduction
8.2.5 Writing the Discussion and Conclusions

Lesson 8.3 Writing the Paper
8.3.1 Planning the paper
8.3.2. What are the figures? Tables? When to use each
8.3.3. What is the “punch line” of the paper?
8.3.4 Writing and editing
8.3.5 Remove all references to “me”!

Lesson 8.4 The classroom review process
8.4.1 Assembling the “editorial boards”
8.4.2 Assignment of tasks based on “expertise”
8.4.3 Writing the scientific review
8.4.4 Responding to the review

Lesson 8.5 The Oral Presentation of the Project
8.5.1 Development and refinement of powerpoint presentations
8.5.2 Choice of fonts, colors and layout for maximal impact
8.5.3 How to keep the attention of the audience

IV. Course Assessment

Assessments will be directed toward achievement of lab skills as well as content areas. Each assessment will be worth a set number of points and a student’s grade will be based on the percentage of total points scored. Assessments will include, but are not limited to, homework, participation, lab work, notebook, and lab reports and quizzes essays, outlines, summaries, technical drawings, flowcharts, reports, posters, statistics problems and proficiency exams in statistics. A model scientific paper will be reviewed by a student review panel. Students will be assessed for both the quality of the publication and their performance in the review process. A safety assessment must be successfully completed before lab activity can begin. The components of the grade are below.

Grades are composed of four components of equal weight, each assessing a separate skill:

1) **Written Assignments = 25%**

Assesses ability to gather ,organize , and present ideas in a written format.

Students will be required to develop their research idea into the form of a scientific publication. This will be critiqued by a group of students from the class acting as a review panel. The review panel will make their assessment of your paper in writing. All students will act as both submitter and reviewer. Both the paper and the reviews will contribute to this aspect of the grade.

2) **Projects = 25%**

Assess ability to develop an observation into a testable scientific hypothesis and to work with others to achieve a common goal.

These courses will be project driven. Students will define and develop a project based on a scientific hypothesis and present it as powerpoint / oral presentation. The quality and clarity of the project and the presentation will be assessed.

3) **Quizzes and exams =25%**

Assess ability to comprehend information from a variety of sources and recall it at a later time.

Throughout the course the student will receive objective tests on the content, particularly the use of statistics in research study design. These tests will include multiple choice, matching, and short answer questions. Homework assignments will also be included in this category.

4) **Participation = 25%**

Assess ability to verbally state and defend your ideas to critical audiences.

Daily performance in class will be evaluated as well. Students are expected to take an active participatory role in the class. It is not required to have all the right answers. In research, asking constructive questions counts just as much as answering them, maybe more. Every student will start with a participation grade of 75. At the conclusion of every class, your performance will be evaluated. If you were an active participant, a one point credit will be added to your participation grade. If you choose not to engage yourself, your grade will remain unchanged

Participation grade will be reduced by one point for each infraction of the following codes:

1) All in-class and home assignments must be completed.

2) Respect must be shown by not interrupting a teacher or a peer who is addressing the class.

3) Appropriate language must be used at all times in class.

4) You must come to class prepared to participate. Required materials should be at hand.

5) No food or drink in class.

6) Respect must be shown for the property and persons around you.

7) You must be present when the class begins.

EXTRA CREDIT

• No extra credit can be added to any grade lower than an 80 before that assignment is redone and receives a new grade over this mark. A new grade for the assignment will be calculated based on the average of the two grades. When this is completed, extra credit can be earned for this assignment.

• Extra credit assignments will be offered on a regular basis. For example, doing a literature search on a study unit (e.g., analysis of the human face) and submitting a well written synopsis will earn extra credit. Each can earn up to five points towards any grade except the participation grade. There is no limit on how many can be done, but all grades cap out at 100

Assessment Tools

	Assessment 1	**Assessment 2**	**Assessment 3**
Outcomes Assessed	5.1A1 5.1A2 5.1A3 5.1B1 5.1B2 5.3D1 8.1B3 8.1B5 8.1B9	5.1A1 5.1A2 5.1A3 5.1B2 5.3D1 8.1B3 8.1B5 8.1B9 8.1B2	5.1A1 5.2B2 5.5C3 8.1A9 8.1B4 8.1B8
Content Covered	**Independent Research (scientific Paper)**	**Panel review Of the Scientific Paper**	**Powerpoint/ Oral Presentation**
Assessment Format	Research presentation and paper	Group, Critique a Paper, report	Excell, graph, Conclusion, clarity
Percentage Weight of Overall Assessment	50%	15%	20%
Month Assessed	Nov - Jan	Feb	March

V. Resources

Texts

Primary texts will be:

1) *RIP-ing Through Scientific Inquiry: Critical Thinking and Effective Decision Making Skills for Middle School and High School Science Education.* Robert Landsman, Ph.D., ANOVA Science Publishing, 2005

2) *Data Analysis and Decision Making in Scientific Inquiry: A Statistical Approach for Middle School and High School Science Education.* Robert Landsman, Ph.D., ANOVA Science Publishing, 2005.

3) The Art of Science: A Practical Guide to Experiments, Observations, and Handling Data by Joseph J. Carr, 1989.

4) Additional scientific publications as assigned by the course director

Other Reference Material

Video tapes and DVDs explaining the concepts of measurement, variance and standard deviation will also be used.

Ardley, N., Dictionary of Science, Dorling Kindersley Limited, London,192pp.,1994.

Farndon, J., Dictionary of the Earth, Dorling Kindersley, London, 192 pp., 1992.

Kramer, S. P., How to Think Like a Scientist, Thomas Crowell, New York, 44 pp., 1987.

Limburg, P. R., Oceanographic Institutions, Elsevier/Nelson Books, New York, 265 pp., 1979.

Tobias, S., Can C. T. Tomizuka, Breaking the Science Barrier, How to Explore and Understand the Sciences, College Entrance Examination Board, New York, 163 pp., 1992.

Websites

www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=Books NCBI Bookshelf
www.statsoft.com/textbook/stathome.html Statistics Electronic textbook
www.statistics.com/ Info about statistics
/www.lib.umich.edu/govdocs/stats.html Statistical Resources
physics.web.cern.ch/Physics/DataAnalysis/BriefBook/ Data analysis site
http://experts.about.com/e/l/li/List_of_famous_experiments.htm Famous experiments in science
http://www.answers.com/topic/list-of-famous-experiments More experiments

http://www.state.nj.us/education/cccs/2004/s5_science.pdf **New Jersey Core Curriculum Content Standards For Science**
http://www.state.nj.us/education/aps/njscp/Phase1allAreas.pdf#page=13 Standards Clarification Project: All Content Areas Grades K-12

Other web sites will be added as needed.

VI. Methodology

This is a lab courses with a lecture component. The majority of the work will involve a hands-on approach. Lectures will be used to provide background for the experimental work, which will involve physical measurements or importation of data from the internet, followed by tabulation and analysis of the data. Important web sites and interactive CDs will be used to augment the texts, to prepare students for multi-step tasks prior to carrying them out in the lab.

While discussing the problems of lab safety, falsification of data and plagiarism, accurate measurement, and recording of data, the tone of the classroom should be appropriately serious, but beyond in general the tone of the classroom should be informal and progressive. Students should feel free to question each other and the instructor. The teacher can take time during the lab to work one-on-one with students who need extra help, or to informally assess a student's understanding of the material. These discussion/question/idea sessions will assist the students in deciding on their second trimester research. However, all students will be encouraged to have multiple, private disussions with the instructor outside the class periods to determine the research project. For the in-lab experimental work, students will be organized into lab groups, which will change from week to week. Concepts common to cooperative learning strategies will be utilized in these lab groups. Students will be expected to do a considerable amount of outside reading.

The general format of the one-hour class periods will be as follows: Approximately 15-20 minutes to go over readings, questions and lab procedures, followed by 30 minutes of lab work, and finishing up with 10-15 minutes of discussion and suggested approaches to analysis. Much of the analytical work will be performed outside the lab, as assigned homework. Within the group structure in the classroom, some students will be defined (by volunteering or being assigned) as organizer (directs the lab activity and keeps the group on task), obtainer (person who assembles materials), and clean-up (ascertains that the lab is clean when the period is over*). These roles will rotate at each lab session.*

Each class will begin and end with a question and answer/ discussion period. This time will be used in various ways. It may be used to give background material for the upcoming tasks. It may be used to discuss student concerns or to demonstrate a

particular skill. At the end of the lab it will usually be used to ensure that students understand how to analyze and manipulate the data they have obtained.

VII. Connectivity

This course is training students to move quickly and ably into the professional laboratory environment. Students will be exposed to proper lab procedures. Occasionally field trips to working labs may occur.

Appendix One:

Scientific Paper Rubric

Name: **Course:** **Project:**

Date: **Section:**

Components	3 Points	2 Points	1 Point	SCORE
TITLE PAGE	All components required fo page exist and are located	80% or more of the comp necessary for a complete page exist.	60% or more of the compo necessary for a complete t exist.	
ABSTRACT	Approximately one paragra detailed information about report. Contains objectives work.	Does not completely expl report in a concise manne Purpose of the work is st	Does not completely expla report in a concise manne Purpose and objective of t are unclear.	
INTRODUCTION And BACKGROUND	Short brief explanation of t activity is complete and ac Evidence that the student researched beyond the inf given in class. Student has that his/her work is unique research.	Is either wordy, lacking information or not related material in the report. Minimal work was done t research the topic. Evide project is unique is not sh	Is wordy or lacking informa Material is not related to w Student did not research th beyond the classroom. Pro not unique.	
MATERIALS And METHODS	All materials used are described. The step-by-step process exactly as done by the stu Sketches, photos, schema equations, etc. are shown appropriate. All procedures explained in detail and writ third person.	80% of materials used ar A step-by-step procedure Some sketches, photos, schematics, equations, e not necessary. Uses som pronouns. Some details r	60% of materials used are listed. Step-by-step is out of orde are missing. Graphics are unnecessary or missing. L detail to explain the proce	
RESULTS	Student has explained the using equations, tables, dr etc. The results support th objectives. Possible errors explained and suggestions improvement have been m	Student has proven resul credible evidence. The re support the objectives. Er suggestions are not discu	Student results do not mat objectives. Evidence of ho results were obtained is la There is no discussion of e	

Components	3 Points	2 Points	1 Point	SCORE
DISCUSSION AND CONCLUSION	Student has a summary of he/she learned and what t was all about.	Summary is too long or d explain what the student accomplished.	Student has a summary th not match the work in the a	
APPENDIX	All large pieces of informat an appendix. Each append labeled and holds informat as schematics, and drawin	Appendix holds informati does not belong. Append labeled incorrectly.	Drawings and Schematics thrown in the back, are not or do not exist.	
CITATIONS	All information gathered by student has been cited wit proper format.	Some of the sources the used are not cited and ar formatted correctly.	Few sources that were use cited and the format has n followed.	

Appendix Two

Written"Scientific Paper" Report

Reports need to be neat, organized and word-processed. Someone should be able to read the paper and duplicate the results. Reports should be written in the third person with no pronouns. The following components are required":

TITLE PAGE (1 page)

In a list format, the title page should include:

- Title of project
- Names of student participants
- Course title
- Date

ABSTRACT (1/2 page)

Summarize in a paragraph the objectives of the project and what was accomplished. Include specific information to support your point. This one-paragraph summary should be short and to the point with specific information. The major findings of the data analysis should be presented.

INTRODUCTION and BACKGROUND (2 page maximum)

The following questions should be answered in this brief explanation of the project or activities:

- Why is the research question posed in this paper an interesting and worthwhile pursuit?
- What have others learned about this area?
- What is different about what you have done (if anything)?
-

MATERIALS and Methods (5 pages maximum)

List all materials needed to do the project. Bullet the list.

Present details on how you performed the individual steps, assays, procedures, etc. in the project. References (callouts) to sketches, schematics, equations, and photos in the appendix should be included. This section may be broken into subsections. If a published procedure was followed, it must be adequately cited.

RESULTS (5 pages maximum)

What did you find? Explain your goals in doing each measurement or assay and show how the data support or do not support your hypotheses. Each of the main data points should be supported by a figure or table (callouts to the appendix). These should be numbered and arranged in a logical order, with the main point of the paper (the "punch line") being the last figure. Figures should be clear are easy to understand. Each figure should have a figure legend explaining exactly what the figure shows. It is acceptable to have divided figures (1A, 1B, etc.) if the data are related, and it helps to clarify a point. Explain problems that arose and include suggestions for improvement. Discuss the kinds of errors and problems that occurred during the process. Compare your results with your initial stated purpose.

DISCUSSION and CONCLUSION (2 pages maximum)

Address the reason for doing this project. What is the reason for doing the project? Does your result support the results of others in this field? If not, can you speculate on the why your data are different? What do you plan to do next?

APPENDIX

Include the following:

- Drawings
- Schematics
- Pictures
- Tables
- Pertinent information to the report but too large to fit in the written documentation

CITATIONS

Include all resources, such as books, magazines, journal articles, and Internet sources that were used to obtain and learn information. The format should follow APA guidelines.

Appendix Three

"Peer Review" Report Rubric

The "Scientific Paper " from Appendix 2 will be graded by the instructor. Groups of five students picked at random will be assembled as "Peer Review Panels". A Chairman will be elected for each panel, who will oversee the review process. Each panel will receive five papers, written by students who are not panel members, for a critical analysis. Each paper will be assigned by the chairman to two members of the panel for written review. The elements of critical analysis will be discussed by the instructor The panel will critique the paper on adherence to the rules of organization, logic and clarity of presentation and scientific validity, i.e., does the data provided in the paper support the conclusions or not. The chairman will collect the reviews and assemble the panel for a discussion of the reviews. At the discussion, ALL panel members will be able to comment on all papers. These comments will be included in the committee report. A priority score from 1 to 5 will be assigned to the paper by each member of the panel (1 is highest; 5 the worst) and the average score reported in the final report for each paper.

The panel reports for each paper should include the following components.

TITLE PAGE - 5pts.

In a list format, the title page should include:

- Title of project
- Names of the chairman and students on the panel
- Title and Author of the paper being reviewed
- Date

ABSTRACT - 5pts.

Summarize in a paragraph the conclusion of the panel and the basic reasons for coming to this conclusion. The priority score is included in this paragraph. This summary should be short and to the point with specific information and one paragraph in length.

INTRODUCTION

What was the point of the paper reviewed. This can be taken verbatim from the abstract of the paper.

INDIVIDUAL REVIEWS (25 pts each)

Each reviewer adds his written report to the review, assembled by the chairman. The reviewer can be as hostile or generous as they care to be, but they need to justify their comments with sound reasoning. Discuss how well the objectives were accomplished. Include suggestions for improvement and the kinds of errors and problems that were noted. Specific comments should be included as to what is needed to make the paper acceptable, if changes need to be made.

CONCLUSION (5 pts)

The chairman should include any additional comments made by the panel that were not reflected in the written assessments by the assigned reviewers. The review should conclude with a statement regarding whether the reviewed paper should be accepted as is, modified and resubmitted, or rejected outright.