# APPENDIX

# Exploring Spectra
## Constructing a Spectroscope

The shoebox spectroscope takes the light from a slit at one end and passes it through a grating. The grating diffracts or separates the different colors of visible light into the full visible spectrum. It can also be used to examine the spectra of colored light sources.

**To make this simple instrument you will need:**

1. A shoebox or any thing similar to a shoe box (a card board tube will work if you cover the ends with heavy cardboard)
2. An index card cut into 2 parts
3. A diffraction grating slide (see **Supplies and Vendors** in Appendix for source)
4. Scissors or a knife for cutting holes in the shoebox
5. Ruler
6. Glass lens (optional) for clearer appearance of diffracted light
7. Tape or glue
8. A fairly dark environment

**Construction of Spectroscope**

1. Cut one hole, the size of the clear portion of the diffraction grating (2.5cm X 2.5cm), on one end of your shoebox.
2. Hold the diffraction grating near your eye and look toward a light. You should see a spectrum to the side of the light. If the spectrum is above and below the light, rotate the grating 90° and tape the diffraction grating over the hole as shown.
3. Cut another hole on the opposite side of the shoebox that is .5cm to 1cm wide and 4cm high.
4. Tape the two pieces of index card over the new hole so that the index cards almost touch. Leave a tiny gap between the index cards about two to four thickness of the index card (about 1mm)
5. Put the lid on the shoebox.

To check your spectroscope, aim the slit at a fluorescent ceiling light and look through the grating end (**Never look directly at the Sun**). You should see a spectrum with four prominent lines (violet, blue-green, green, red) off to one side.

## A Modified Ritter Experiment:
## Discovering Ultraviolet Light

**Purpose:** Determine what region of the light spectrum causes the special beads to change color.

**Materials:**

4. 1 Equilateral **glass** prism
5. Prism holder (optional)
6. 6- 10 special beads (UV beads-see **Supplies and Vendors** for source)
7. Thick shoelace (black, if possible) approximately 12 inches long
8. Tape- may be needed to hold prism in notch
9. Cardboard box with lid (a photocopier paper box works very well)
10. White paper for bottom of box
11. Scissors or sharp knife
12. Flashlight

**Procedure:**

a. Cut a notch out of the top edge of the box on one of the narrow ends. The notch should hold the prism tightly and still allow it to rotate slightly.

b. In the lid of the box cut a flap that is about one inch wider than the prism notch. The flap should extend about 6 inches toward the middle of the box. Score the flap slightly along its line of attachment to rest of the lid and score it again slightly about 3 inches from the line of attachment. This will allow the flap to bend easily. The flap will allow you to look into the box without letting in reflected light from the sky.

c. Prepare special beads in a location out of direct sunlight. Cut shoelace in half. Tie a knot in the cut end. Thread one bead onto the lace and slide it to the knot. Tie another knot so that the bead is held firmly between the knots. Continue to add beads and knots until the shoelace is full. Tie a final knot to keep all of the beads on the shoelace. Put beads and shoelace in a black film canister.

d. Take box, prism, and film canister with beads outside on a sunny day.
e. Install the prism in the notch and point the prism end of the box toward the Sun. Rotate the prism slightly until a clear spectrum is visible on the bottom of the box. You may have to prop up the end of the box slightly to get the spectrum in the box. Carefully, put on the lid.
f. Put the canister in through the flap, remove the beads and shoelace, and lay the beads in the spectrum so that each bead is in a different color and one end bead is in the dark region just outside of the violet. Be very careful not to allow any reflected light from the sky hit the beads.
g. Replace the flap so that only direct sunlight passing through the prism can get into the box. Leave for 3-5 minutes.
h. Carefully, lift the flap and look at the beads. (You may need to use a flashlight to see inside the dark box.) Record which bead or beads have changed color.

## Prediction Reflection

Within the activity you have completed were instructions to predict the outcome of an experiment. There is no correct or incorrect answer to these predictions. However, it can be very helpful to your understanding of the concepts if you understand why your prediction matched or did not match the experimental outcome. In this journal entry you will choose two predictions to reflect upon. You should write about one prediction that did not match the outcome and one prediction that did match the outcome. (However, if every prediction matched every outcome or every prediction failed to predict every outcome, choose two that are interesting to you.)

Guidelines are simple:

1. Explain what made you believe that your prediction was true. Have you had similar experiences, did you read about this experiment somewhere, has someone explained this concept to you, did you connect this activity with one you have experienced, did it just seem natural (why?), did you just wildly guess?
2. What did each of these predictions tell you about how you think about this concept? Describe what you learned (if you learned nothing, it is alright to say that... try to explain why).

3. This is not a "journal" in the sense that you would record the events of the day. These reflections are a chance to privately explore some of the questions we consider and your reactions to the ideas and experiences you encounter. It is a chance to think about how you think and learn. Don't worry about "being right" or saying something "stupid." Explore the problems and ideas that are of interest to you; examine your reactions, habits, opinions, and assumptions.

This reflection will be evaluated on the depth of your thinking. You should write 1-2 pages (assuming about 300 words per page). It is perfectly permissible to ask questions and to suggest further investigations that you think might help you to understand the ideas better.

## Lab Report Format

Evaluative Criteria

**Purpose:** One or more concise sentences stating the question or questions that are to be answered by this investigation. The purpose should help you to focus your attention on important relationships. This will take the form of a thesis statement and the supporting assertions

| | | |
|---|---|---|
| 8-10 points<br>thesis statement and <u>all</u> supporting assertions clearly stated with no extraneous detail | 4-7 points<br>thesis statement with one or more supporting assertions missing, understandable but not clear, inclusion of <u>some</u> extraneous detail | 0-3<br>missing purpose, missing or incorrect thesis statement, no supporting assertions (if there are some), not understandable, inclusion of much extraneous detail |

**Procedure:** The procedure is a step-by-step description of activities necessary to gather information to achieve the purpose of the experiment. If you have been given a written procedure, do not write a procedure in your report unless you have deviated from the instructions significantly. If you have deviated from the instructions, indicate what you did differently. Sometimes you may be asked to write a summary of the most important steps.

| | | |
|---|---|---|
| 8-10<br>concise, relevant detail, accurate sequential order, appropriate to achieve desired results, easily read | 4-7<br>insufficient detail or too much detail, won't achieve purpose, unclear directions | 0-3<br>(If a procedure is unnecessary, no points will be given for a procedure.)<br>missing procedure, not understandable, lacks detail, won't achieve purpose |

## Lab Report Format Evaluative Criteria: continued

**Errors:** You must measure carefully, follow directions precisely, and set up your equipment with care. Still, no matter how carefully we measure, there are limits to the accuracy of our devices. Errors no not include doing a trial incorrectly! If you know you have erred in the execution of the experiment, do it over again. Errors are unavoidable inaccuracies in measurements or unavoidable conditions that affect results. You must state the source and estimate the size of the most significant errors affecting your lab.

| 11-15 | 5-10 | 0-4 |
|---|---|---|
| includes all significant errors, correctly estimates the size of errors, does not include frivolous errors, is well written | includes most significant errors, size estimates are within a reasonable range, may contain some frivolous errors | does not include significant errors, does not include numerical estimate, contains many frivolous errors, lacks clarity |

**Data:** All observations (qualitative and quantitative) and the data that you measure or collect directly in the lab must be recorded immediately. This is called "raw data". Often a table can present the data most effectively. In many cases the raw data must be "processed" before valid conclusions can be reached. This processing of data may be mathematical or graphical.

| 26-35 | 11-25 | 0-10 |
|---|---|---|
| complete, clearly presented, correctly manipulated, well organized, properly labeled, thoughtful and effective mathematical and/or graphical treatment | missing some data, weak mathematical or graphical treatment of raw data, not well labeled, missing units | missing data section, disorganized, no labels or units, lacks mathematical or graphical treatment of raw data |

## Lab Report Format Evaluative Criteria: continued

**Conclusions:** In science the conclusion is an interpretation of the data. It is new information which you believe to be true, which you did not know before you did the lab and which is supported by the data. The conclusion should be the answer to the purpose. The conclusion should be in the form of an essay with a thesis statement and supporting assertions. Each must be stated separately and clearly and must be supported by data. Do not merely state the conclusion and then tell the reader that the data proves the conclusion true. Prove to your reader that the data proves the conclusion true. Cite the evidence directly in the conclusion even if it means repeating or copying certain selected parts of the data.

| 26-40 | 13-25 | 0-12 |
|---|---|---|
| correct thesis and supporting assertions, realistic interpretation, relevant and meaningful, complete, concise, terms well defined, considerable support of assertions, ideas vigorously expanded, appropriate use of data, good internal structure with units of thought carefully interrelated for the reader. | weak thesis, weak supporting assertions, vague definitions of key terms, some points of support not well related to thesis or each other, slight breakdown in internal structure, oversimplification of ideas | lack of clearly defined thesis and support not carefully related, structural breakdown, imprecise word choice |

# Journal Article
# Evaluative Criteria

**Title: (2 points)**

Use a descriptive title that is clear. Provide your name and a date.

**Abstract: (8 points)**

The abstract is a "mini-article". It must include the major points of the Introduction, Materials and Methods, Results and Conclusion sections. A fellow scientist should be able to read only this and know the important facts.

| 6-8 | 3-5 | 0-1 |
|---|---|---|
| concise, contains relevant information from each section, well-written and clear | insufficient detail or too much detail, missing one section, lacking some clarity | not provided or providing very little information or lacking clarity |

**Introduction: (20 points)**

You must introduce your reader to the subject under investigation. Give background to the problem, include "library" research you have done, theoretical framework underlying the problem and any other information necessary for the reader to understand the question you are investigating. Then state the exact question you are attempting to answer.

| 15-20 | 6-14 | 0-5 |
|---|---|---|
| Well written, background information is complete, develops understanding of central information, clearly states question | Writing unclear or background information not complete or not accurate, fails to clearly state question | Intro not present, question not appropriate to investigation, not enough explanation of background |

## Journal Article Evaluative Criteria: continued

**Materials and Methods: (20 points)**

Provide a prose description of what you did, how you did it, and what tools you used. The reader should be able to replicate your experiment precisely from this description. Do not, however, make this a "diary"; it is a set of instructions. Sample calculations should be provided in this section. A sample calculation is one without numbers that shows the math used to calculate results.

| 15-20 | 6-14 | 0-5 |
|---|---|---|
| concise, relevant detail, accurate sequential order, appropriate to achieve desired results, easily read | insufficient detail or too much detail, won't achieve purpose, unclear directions | missing procedure, not understandable, lacks detail, won't achieve purpose |

**Results: (20 points)**

Provide charts of raw data, charts of calculated data, graphs when appropriate and drawings which are important, explanations of charts and graphs, and explanations of important results. Errors are presented and explained in a systematic order. The Results section is not a copy of your raw data; it is neat reorganization of the data to make it clear and understandable. Results should be presented to make patterns and trends obvious.

| 15-20 | 6-14 | 0-5 |
|---|---|---|
| complete, clearly presented, correctly manipulated, well organized, properly labeled, thoughtful and effective mathematical and/or graphical treatment, includes all significant errors, correctly estimates the size of errors | missing some data, weak mathematical or graphical treatment of raw data, not well labeled, missing units, includes most significant errors, size estimates are within a reasonable range | missing data section, disorganized, no labels or units, lacks mathematical or graphical treatment of raw data, does not include significant errors, does not include numerical estimate |

## Journal Article Evaluative Criteria: continued

**Conclusions: (20 points)**

In science the conclusion is an interpretation of the data. It is new information which you believe to be true, which you did not know before you did the lab and which is supported by the data. The conclusion should be the answer to the purpose. The conclusion should be in the form of an essay with a thesis statement and supporting assertions. Each must be stated separately and clearly and must be supported by data. Do not merely state the conclusion and then tell the reader that the data proves the conclusion true. Prove to your reader that the data proves the conclusion true. Cite the evidence directly in the conclusion even if it means repeating or copying certain selected parts of the data.

| 15-20 | 6-14 | 0-5 |
|---|---|---|
| correct thesis and supporting assertions, realistic interpretation, relevant and meaningful, complete, concise, terms well defined, considerable support of assertions, ideas vigorously expanded, appropriate use of data, good internal structure with units of thought carefully interrelated for the reader. | weak thesis, weak supporting assertions, vague definitions of key terms, some points of support not well related to thesis or each other, slight breakdown in internal structure, oversimplification of ideas | lack of clearly defined thesis and support not carefully related, structural breakdown, imprecise word choice |

**References: (10 points)**

You must give credit for any information that you cite in **any section** of the article that is not from your own mind or experimentation. This includes information from a textbook. Within the body of the text (for example, in the Introduction) you will cite the source (Author, date) or (Editor, date) if no author

is available. At the end of the article you must provide a bibliography of every source you cited in the article. Do not provide bibliographic information for a source never cited in the text. Use the following bibliographic form

Bueche, F & Jerde, D. *Principles of Physics.* New York: McGraw-Hill, 1995

Hu, H & Yu, J (2000). "Another Look at Projectile Motion" The Physics Teacher", 38:423-424
*(38:423-424 means volume 38, page 423-424)*

Fowler, Michael. "Aristotle." *Galileo and Einstein Lecture Notes* <http://galileoandeinstein.phys.virginia.edu/lectures/aristot2.html; date used

# PowerPoint/Webpage/ Poster Presentation

## Evaluative Criteria

**By Kris Deardorff**

| PowerPoint/Webpage/Poster | Possible points | Your points |
|---|---|---|
| Accurate Information | 6 | |
| Thorough Explanation | 6 | |
| Current Research | 6 | |
| Relevance | 6 | |
| Quality Science | 6 | |
| Attractive Design | 6 | |
| Effective Design | 6 | |
| Correct Spelling and Grammar | 6 | |
| Appropriate Length | 6 | |
| Correct Citations (at least 3 sources) with Correct Bibliography | 6 | |

| Presentation of PowerPoint/Webpage/Poster | Possible points | Your points |
|---|---|---|
| Accurate Information | 5 | |
| Thorough Explanation | 5 | |
| Current Research | 3 | |
| Relevance | 2 | |
| Quality Science | 5 | |
| Use of Visual Aids (in addition to PowerPoint/Webpage or Poster) | 5 | |
| Engaging Enthusiasm | 5 | |
| Clear, articulate and organized presentation | 5 | |

| | | |
|---|---|---|
| Appropriate Use of Time | 5 | |

| | | |
|---|---|---|
| TOTAL | 100 | |

# PEER REVIEW IN THE SCIENCE CLASSROOM

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**GUIDELINES**

The goal of peer review is to provide a creator/presenter with productive critique in as gentle a manner as possible. It is important to the process that the creator/presenter is placed in the position of power and controls the process.

To create an environment that supports this goal the following process is recommended.

The creator/presenter is accompanied by a "secretary" of her/his choice who's job it is to record the questions which will be asked by the reviewers.

**The creator/presenter describes or reads the item to be critiqued (for example: a laboratory procedure for a proposed experiment.)**

**After the presentation of the material to be critiqued, the other students are only permitted to ask questions of the creator/presenter. *This is the essence of the process.* Questioning, though often difficult, opens discussion while statements close the discussion.**

**The creator/presenter controls the flow of questions and the secretary records the questions.**

**In response to a question the creator/presenter has two options: 1) to answer the question directly or 2) to say something similar to "Interesting question. I'll have to think about that".**

**After the questioning session the secretary provides the creator/presenter with the list of questions for her/his later review.**

Individuals or small groups of students may be the presenter(s). The process may be done with the entire class asking questions or with a small group (4-6 students) acting as reviewers. If a small group reviews, it is suggested that those students take responsibility for their review by having their names placed on the final document as "reviewed by".

Peer Review: continued

Upon completion of the review process the creator/presenter may utilize or reject any ideas discovered during the review process. The acceptable ideas are then incorporated into the original document and a final draft is created.

**THE VALUE OF PEER REVIEW IN INQUIRY SCIENCE**

Some of the possible benefits of Peer Review for the CREATOR/PRESENTER:

- **There are more minds working on the problem or question**
- **The creator/presenter may gain clarification of her/his ideas**
- **Discussion of experimental variables, experimental design, number of trials or subjects and statistical validity may occur.**
- **The accuracy of the document may be improved.**
- **The authenticity of the scientific and technological research process is more closely achieved. ***
- **There may be an increase in the creator/presenter's accountability for her/his work.**
- **The creator/presenter may gain confidence.**

Some of the possible benefits of Peer Review for the REVIEWERS:

- **Ideas may be expressed to the creator/presenter that are directly applicable to someone else's proposed experiment.**
- **Discussion of experimental variables, experimental design, number of trials or subjects and statistical validity may occur.**
- **Students may model good scientific processes for each other.**
- **A reviewer's listening skills may be improved.**
- **Class discussion may improve communication between class members.**
- **Reviewers may be challenged to think beyond their own ideas**

Many business organizations and scientific institutions employ peer review to ensure success. NASA, for example, implements peer reviews at many points in a project's development from early concept design and instrument selection to final design and testing.

# Independent Investigation

Choose a question about light or the light spectrum and design and conduct an experiment to answer the question. You may choose a question from Journal Assignment #4: How are Parts of the Spectrum Different?, or you may develop a different question after your investigations during **Getting Hotter?** and **Mystery Light**. Choose a question that is interesting to you.

| Date Due | Complete | Task | Notes |
|---|---|---|---|
| | | Preliminary experimental design procedure completed | |
| | | Peer Review – design procedure must be complete, written and copied for review team | |
| | | Revised procedure completed | |
| | | Materials list completed and presented to teacher | |
| | | Data collection completed | |
| | | Rough draft of presentation | |
| | | Presentation of results | |

APPENDIX

**5Es**

| | Suggested Activity | What the Teacher Does | What the Student Does |
|---|---|---|---|
| Engage | • Demonstration<br>• Reading<br>• Free Write<br>• Analyze a graphic organizer<br>• Brainstorming | • Creates interest.<br>• Generates curiosity.<br>• Raises questions.<br>• Elicits responses that uncover what the students know or think about the concept/topic. | • Asks questions such as, Why did this happen?, What do I already know about this? What can I find out about this?<br>• Shows interest in the topic. |
| Explore | • Perform an investigation<br>• Read authentic resources to collect information<br>• Solve a problem<br>• Construct a model | • Encourages the students to work together without direct instruction from the teacher.<br>• Observes and listens to the students as they interact.<br>• Asks probing questions to redirect the students' investigations when necessary.<br>• Provides time for the students to puzzle through problems. | • Thinks freely but within the limits of the activity.<br>• Tests predictions and hypotheses.<br>• Forms new predictions and hypotheses.<br>• Tries alternatives and discusses them with others.<br>• Records observations and ideas<br>• Suspends judgment. |
| Explain | • Student analysis and explanation<br>• Supporting ideas with evidence<br>• Structured questioning<br>• Reading and discussion<br>• Teacher explanation<br>• Thinking Skill Activities: | • Encourages the students to explain concepts and definitions in their own words.<br>• Asks for justification (evidence) and clarification from students.<br>• Formally provides definitions, explanations, and new | • Explains possible solutions or answers to others.<br>• Listens officially to others' explanations.<br>• Questions others' explanations.<br>• Listens to and tries to comprehend explanations the teacher offers.<br>• Refers to previous |

| | | | |
|---|---|---|---|
| | compare, classify, error analysis | labels.<br>• Uses students' previous experience as basis for explaining concepts. | activities.<br>• Uses recorded observations in explanations. |
| Extend | • Problem solving<br>• Decision making<br>• Experimental inquiry<br>• Thinking Skill Activities: compare, classify, apply | • Expects the students to use formal labels, definitions, and explanations provided previously.<br>• Encourages the students to apply or extend the concepts and skills in new situations.<br>• Reminds students of alternative explanations.<br>• Refers the students to existing data and evidence and asks, What do you already know? Why do you think…?<br>• Strategies for Explore apply here also. | • Applies new labels, definitions, explanations, and skills in new, but similar situations.<br>• Uses previous information to ask questions, propose solutions, make decisions, and design experiments.<br>• Draws reasonable conclusions from evidence.<br>• Records observations and explanations.<br>• Checks for understanding among peers. |
| Evaluate | • Any of the above<br>• Develop a scoring tool or rubric<br>• Test<br>• Performance assessment<br>• Produce a product<br>• Journal entry<br>• Portfolio | • Observes the students as they apply new concepts and skills.<br>• Assesses students' knowledge and/or skills<br>• Looks for evidence that the students have changed their thinking or behaviors<br>• Allow students to assess their own | • Answers open-ended questions by using observations, evidence, and previously accepted explanations.<br>• Demonstrates an understanding or knowledge of the concept or skill.<br>• Evaluates his or her own progress and knowledge. |

| | | | |
|---|---|---|---|
| | | learning and group-process skills.<br>• Asks open-ended questions, such as: Why do you think…? What evidence do you have? What do you know about x? How would you explain x? | • Asks related questions that would encourage future investigations. |

# Supplies and Vendors

Diffraction gratings-
Edmund Scientific http://www.edmundscientific.com
Sargent-Welch http://www.sargentwelch.com

Student Spectroscopes-
Learning Technologies, Inc http://www.starlab.com
Sargent-Welch http://www.sargentwelch.com

Spectroscope kits-
Learning Technologies, Inc http://www.starlab.com

Spectrum tube power supply-
Sargent-Welch http://www.sargentwelch.com
Edmund Scientific http://www.edmundscientific.com

Spectrum tubes-
Sargent-Welch http://www.sargentwelch.com
Edmund Scientific http://www.edmundscientific.com

Glass prism, equilateral-
Edmund Scientific http://www.edmundscientific.com
Sargent-Welch http://www.sargentwelch.com

Spectrum glasses-
Educational Innovations http://www.teachersource.com

Alcohol thermometers-
Sargent-Welch http://www.sargentwelch.com
Ward's http://www.wardsci.com

UV Beads-
Educational Innovations http://www.teachersource.com

AtomicMac™- resource software that provides information, including emission spectra, for all of the elements. Available in Mac and Windows versions for $25.
http://www.blackcatsystems.com/software/atomic.html

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