Changes From Last Year

This document contains no significant changes from last year’s.

Judging: The Big Picture

Science Fair “category judging” has many goals. Our ultimate goal is to rank the projects into 1st, 2nd, 3rd, . . . places within a category and then to choose the overall Fair winners from the category winners. We accomplish this goal by using a huge number of judges to rate each project with scores that run from 0 to about 180 points.

Note that “category judges” differ from “special [award] judges” in that the category judges are ranking the participants in categories whereas special award judges are seeking projects with special properties (e.g., “Best photographs”, “Most ecological”, “Best use of robotic technology”). This handbook is for category judges; each special award has its own criteria and methodology for judging.

A “Project” is an investigation for science folks and a constructed project for engineering students.

IMPORTANT POINTS

If you read nothing else in this document, please read the boxes like this one.

Other goals include:
• encouraging Fair participants to continue to pursue their interests in Science,
• rendering advice on how to leverage students’ skills and desires, and
• sharing judges’ knowledge with the participants.

Of course, it’s always a goal for everyone to enjoy their day at the Fair.

The students are competing for recognition, trophies, ribbons, cash prizes, special awards, and sponsored trips both to the Colorado State Science and Engineering Fair and the International Science and Engineering Fair.

MAIN CATEGORY JUDGE GOAL

Rate, then rank, the top students in each division and overall (for prizes) and encourage all competitors to keep up the good work.
Some Details

To achieve a ranking, judges rate (give a score to) the student’s work in planning and executing a science project, their oral presentation, their backboard, and (to an extent) the results of their experiment or project. After the judging phase, judges meet in the deliberation phase to rank the students in their divisions and, subsequently, determine the overall winners in the junior and senior divisions.

Each project is judged by several different judges, each of whom assigns a numerical score and assessment of effort and special innovation level. The aggregate of all (6 or more, generally) judges’ scores is massaged statistically to find a provisional rank for a given student (thus reducing reliance on or impact of any single judge). Committees then choose the category winners and overall Fair winners from the high-scorers.

About Timeliness

One of the most important results a judge provides is a reasonable, fair, timely score for each project he or she judges. Scores that fail to arrive in a timely manner after a round finishes cannot be used to rank the competitors. Spending three hours judging a project would probably yield a ‘better’ or more precise result; unfortunately, we must conduct the Science Fair in an extraordinarily limited timeframe and must do the best job we can in that timeframe. Thus, fear not being off by a point or two either way when judging a project: The other judges for that project will surely average out any slight differences.

JUDGING SCHEDULE

Judges must precisely follow the judging schedule in order to ensure the success of the day-long event – do not skip projects, reorder projects, linger too long, or finish more than a minute or two early. Forms must be turned in to the runners immediately after each Judging Round.

Here is the tentative schedule for this year’s Fair:

- At 9:00 am, judges head from the training lecture hall to get their schedules near Berger Hall, UCCS’s now remodeled former gymnasium.
- Round 1 includes five sessions; the first is 30 minutes (to get used to locations, runners, etc.) while the rest are 25 minutes.
- Morning judging ends at 11:30 or so. Please hang out during the break at the last morning project for five minutes as we scan the forms to make sure they are OK.
Precise lunch schedule and location will be announced on Saturday.
Meet outside Berger Hall again for the afternoon judging schedule around 1:05 and commence afternoon judging at 1:15. Five more 25 minute sessions just like the morning follow.
Hang out at the last project again for about five minutes to ensure your forms scanned correctly.
At 3:15, Finalist and Platinum (overall Fair) judges meet (at a place to be named Saturday) to determine the Fair’s winners.

About Projects
Most PPRSF students create science projects which have a hypothesis and then test that hypothesis by comparing some variant scheme’s properties with ‘standard’ results from a ‘control’. A few students fabricate Engineering projects, which feature development of a device or method along with its evaluation using some absolute measurements (which are often compared to measurements of some similar device).

Science projects carry with them several potentially surprising properties:
• A valid science project is not required to have practical application
• A valid science project might have a hypothesis that’s been rejected
• Science projects might, by chance, reproduce some work already performed by others (anyone from other students through top scientists) in the past. Good projects have a new twist or a different approach or idea.
• Completely original research is hard! It’s not required. However, we don’t reward demonstration projects that merely confirm or demonstrate well-known results (presuming the student knows about them beforehand). It’s OK to “discover” Ohm’s law for a sixth grader. It’s not OK to confirm it as the centerpiece of a project.

Please don’t reduce Science projects’ scores because of impracticality of the project’s final goals (e.g., to cure cancer quickly) or because of a hypothesis whose opposite turned out to be true (unless, of course, this wasn’t recognized). Note that the practicality of the end-result is different from practicality of finding that result – the experiment itself must be able to be completed.

As a brief aside, exhibits that appear as if they were created by a professional might actually be created by a professional! Try to assess this carefully.

### PROJECT TYPES

Projects judged as ‘science’ projects have a hypothesis, experimental observations, and results/analysis. Projects judged as ‘engineering’ projects create some new entity which is then evaluated according to contestant-specified criteria.
**Group Projects**

Some projects are created by two or three students instead of just one. These projects are scored identically to single-person projects and compete head-to-head with them.

However, if one or more of the group is not present, be sure to mark that on your score card. If you wish, you can inform them that they are not eligible for category awards if any of their members is absent. Continuing the scoring and discussion, but they will not earn any category awards.

**Encouragement**

Nothing turns a student to a non-science career faster than suffering through Simon Cowell-like criticism at a Science Fair. Please leave every student with a positive attitude about his/her project and the Fair [4].

**ENCOURAGEMENT**

Please praise and encourage the competitors; avoid all but the most constructive criticisms if at all possible.

**PPRSF Judging Philosophy**

Like football polls and beauty contests, ranking Fair contestants contains an element of personal subjectivity. The PPRSF mitigates this in several ways:

- By using forms with extremely detailed point allocations that enable judges from widely varying backgrounds to arrive at similar or identical scores for a project, even when judging at different times.
- By judging each project with several judges independently. These judges’ scores are combined to form the project’s score.
- ‘Finalist’ judging committees include judges who have seen almost every project to be considered for awards and thus enable ‘baseline judging’ where projects are ranked above or below each other only by those who have seen both projects.

These three points combine to form the backbone of the Fair’s credibility, fairness, and ranking defensibility.

Of course, student presentations and familiarity with their project at 9:10 AM on Fair day are dramatically different than at 2:00 PM after they have spoken with the better part of a dozen judges. This is just the way Fairs work.

Judging takes place across two very similar rounds. The first and second round forms were combined into one comprehensive judging form starting in 2009.

Judges generally judge in their assigned category of expertise throughout the fair schedule (or at least their general area – life science or physical sciences). At the lunch break, scores are sorted so that the afternoon schedules ensure that Finalist Judges and Platinum Judges see the top-ranked projects in each category.

PPRSF believes in ‘baseline’ judging that requires finalist judges to make a direct, personal comparison between sets projects before those projects are declared as Category or Fair winners.
The 2006 Fair marked a departure from traditional science fair judging criteria like: “Science and engineering thought,” “Clarity and drama of the display,” “Skill,” “Concept originality,” and “Thoroughness.” Why? Because the abstraction level of those concepts is so high that without concrete guidance, one might award almost any project a wide range of perfectly justifiable scores.

Furthermore, each of those abstract categories requires evaluating the entire project before a score can be ascertained. This is at odds with the normal flow of project judging in which a student gives a brief oral presentation followed by a discussion with the judges.

The judging forms contain sections that mirror the flow that a judge can use to guide discussion: project selection, procedure, and execution. They also have sections for the student’s communication, results, and interview.

**METHODOLOGY**

Each project is judged by many judges – don’t worry about making a small mistake. Two similar judging rounds of five projects each today.

**Vocabulary**

Some quick definitions:

- The *participant, contestant, or student* is the person whose Science Fair project is being judged. They are 6th through 12th graders (generally 11-18 years of age). When more than one person created the project, it is a *group project* and is judged exactly as other projects, with the additional proviso that all group members should be participating.
- This document uses *project* to refer the experiment, constructed entity, or whatever entity is the focus of any given student’s entry.
- The *backboard* is generically all the presentation materials that a student uses to display his/her project.

**Measurement**

Measurements make up an important piece of almost every Science Fair project. The terms *accuracy, precision, and resolution* are handy to discuss measurements.

- *Accuracy* pertains to the absolute error of a measured or calculated value. Better accuracy means a smaller deviation from the variable’s exact value (and better accuracy is often highly regarded).
- *Precision*, for our Fair, refers to the number of digits a measurement produces. More precision is not always better! Consider the idea of stating that a book weighs 0.91359213985721385 kilograms. If the book weighs 1.0 kilogram, the measurement was very precise but not very accurate. Many students confuse precision with accuracy and claim very high precision measurements whose accuracy falls off after two or even fewer significant digits.
- *Resolution* refers to the ability of a measuring device to separate two very close measurements. For example, if a time interval counter has a resolution of 10 ns, it could produce a reading of 3340 ns or 3350 ns.
but not a reading of 3345 ns. Instruments are rarely more accurate than their resolution.

Judging

Part of the judging is designed to determine whether the student followed the basic precepts of a science (or engineering) project. Do they have a backboard? Did they cite the hypothesis? Did they collect and analyze data? Did they draw a valid conclusion?

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**APPROPRIATE TO AGE GROUP**

**IMPORTANT:** Many questions are marked “appropriate to age group.” Judge competitors as members of their peer group, not against Newton and Einstein (or yourself).

Our goal in judging is to get a spread of scores (ratings) so that we can sort their aggregate into rankings. Do not fear giving someone a great score, an average score, or a below-average score (even a score close to 0). These forms are shared by both junior and senior students and must distinguish among the very best of the competitors at the highest level in addition to working for the worst projects at the lowest level. Some lower level students will receive fairly low scores – and that’s fine. They are competing with their peers, not the higher-scoring senior group.

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**ABOUT LOW SCORES**

Each year, some judges award near-perfect scores to most of their judged projects/students. “Oh, they worked so hard.” These scores contribute nothing to the overall rating or ranking procedure. Please tally each of the almost three dozen criteria by thoughtfully evaluating the student’s true performance as compared to what you’d expect from a perfect project.

The PPRSF does not judge students based on their grooming, dress, race, gender, relatives, piercings, haircut, tattoos, age, creed, religion, or school attended. We are judging the students and their Science Fair project using a variety of criteria:

- Project Selection
- Solution & Procedure
- Execution and Data
- Communication and Exposition
- Results
- Interview

The point values for these categories (as implemented by the multiple line items in each of them) map nicely to the traditional criteria and have the added advantage of removing redundancy from the scoring.
Steps for Judging a Project

Following a simple checklist will all but eliminate simple errors and engender a pleasant judging experience for all concerned:

**JUDGING CHECKLIST**

**Read this checklist!**

- **Find the judging sticker** for the current round to learn the ID number of the next project to be judged. **Affix it** to a scoring form, preferably without wrinkling it. If you mangle the label bad enough, ask a runner to fetch you another one (and another scoresheet).

- **Find that project** (use the signs on the ends of the tables). All projects are anticipated to be in Berger Hall this year.

- **Introduce yourself and confirm** that the name on the sticker is the name of the contestant. “Hi, I’m Dr. Albert Einstein, and I’ll be judging your project today. You’re Neils Bohr?” Wrong person? Find the proper project!

Exceptions:

- **The project is not present.** Check the “No Project” box on the score sheet; hand the sheet to a runner. Browse other projects and have pleasant conversations with students or staff. Do not vary your judging schedule; wait until the appropriate time to judge others on your list.

- **The project is present but no student(s) is(are).** Ascertain what’s going on (perhaps there’s a note? perhaps their neighbor knows?). If, after waiting a few minutes, it appears no student will be present, check the “No Student” box on the score sheet and hand it to a runner. Browse other projects and have pleasant conversations with students or staff. Do not vary your judging schedule; wait until the appropriate time to judge others on your list.

- **A group project is missing one or more of its members.** Explain that the project will not be considered for category prizes since not all members are present. **Check the ‘Incomplete Group’ box and conduct a normal encouraging interview with regular scoring.**

- The student probably has a short presentation; let them talk for no more than **THREE MINUTES**. Really: **CUT THEM OFF AT 3.0 MINUTES.**

- Work your way through a discussion of the items on the judging score sheet, marking points as you assess the project’s strengths. Of course you can always change the points as you learn more about the project.

- Three to four minutes before the end of the round (an announcer will remind you), finish up with the student and complete marking and creation of the feedback form.

- Write a few positive remarks and **no more than one constructive criticism** (e.g., “Next year, you might consider taking multiple observations in order to confirm the effect of the stimulus.”). Of course, you
can omit the criticism if you wish. Generally, folks hate being criti-
cized, of course.
• Find a runner (they wear distinctive hats) and give your score sheet to
  them for transport to scoring headquarters.
• Commence judging the next project (and start over at the beginning of
  this list).
• For the final project in the morning and afternoon, please linger for
  about five minutes while your form is checked for proper scanning.

**Demonstration Projects**

A “Demonstration Project” is one in which a student merely repro-
duces some result or project, e.g., the construction of an electromagnet
without adding any innovation at all. Some demonstration projects are
quite elaborate. The 2005 Fair featured a demonstration project that isolated
genes responsible for dyslexia. While a fabulous work with meticulous
effort, it was nevertheless a very weak project vis a vis science since noth-
ing remotely new was envisioned, created, tested, or hypothesized – it was
a strict reproduction of well-known (to some) procedures from the annals
of science – and the student knew this. The judging forms are designed to
preclude demonstration projects from placing highly at the Fair. If you see
one, please write “Check this project (demonstration)” on the lower left of
the back side of your scoring form so our backup judges can make sure all
is well.
The Assignment Sheet

Assignment Sheet

This section tells how the assignment sheet and score sheet work – don’t miss the important bits!

Below is a typical morning assignment sheet (from a year that featured six morning projects; this year has but five).

Andrusiv, Lubov 0339 MORNING Finalist Judge 2015

M1 9:10 am SCI
Wesley Correll
Choosing the best ionic liquid for a fuel cell
0339 Andrusiv, Lubov
START HERE
M1-G6 M2-G16 M3-G1 M4-G11 M5-G13 M6-G3

M2 9:40 am SCI
Lauren Rogers
Erosion?
0339 Andrusiv, Lubov
S
M1-G6 M2-G16 M3-G1 M4-G11 M5-G13 M6-G3

M3 10:05 am ENG
Cristian Granados 2015
Put a little spring in your step
0339 Andrusiv, Lubov
8G1
M1-G4 M2-G16 M3-G1 M4-G11 M5-G13 M6-G3

M4 10:30 am SCI
Sarah Shoulders
Teeth staining: How it works
0339 Andrusiv, Lubov
8G11
M1-G6 M2-G16 M3-G1 M4-G11 M5-G13 M6-G3

M5 10:55 am SCI
Dalton Smith
Use the (magnetic) force
0339 Andrusiv, Lubov
8G13
M1-G4 M2-G16 M3-G1 M4-G11 M5-G13 M6-G3

M6 11:20 pm SCI
Hannia Delgado
Where do they go
0339 Andrusiv, Lubov
8G3
M1-G4 M2-G16 M3-G1 M4-G11 M5-G13 M6-G3

0339 MORNING 2015
Andrusiv, Lubov
Finalist Judge

At 3:00, remove this form from your packet and discard it in the trash

Just before each round of judging, you will pick up a sheet with several sticky labels for score reporting. These labels describe each project to be judged and the time to judge it.

Here’s a typical sticky label for a first judging session that starts at 9:10 am (your label might say 9:15 or 9:20 depending on that year’s schedule; this one also has a six project morning schedule):
The various fields are easy to understand:

- **Session Name** is our code for when the session runs (M for morning; A for afternoon).
- **Session Start** tells the time you should be at the described project to start judging.
- **Eng/Sci** tells the student’s idea of whether this is an engineering or science project.
- **Year ID** is there so that we don’t mix up project stickers from previous years.
- **START HERE** appears on the first label, so that you’ll know which one is the starting point.
- **Project ID** tells you which project you should judge.
- **Schedule** (tiny print) is so that we can find you if something goes wrong with your form.
- **Barcode Key** is how the scanner/computer figure out which judge assessed which project (and when).
- **Judge ID** is the number and name of the judge performing the assessment.
- **Title** is the name of the project (use it to verify you’re at the right place).
- **Contestant** is the name of the student (captain, for groups) you will be judging.

### Summary

The assignment sheet of sticky labels tells you where to be and when. Double-check the participant’s name and project ID. Don’t forget the letters for challenge and effort for final scoring. Hand the form to a runner when you’re done.

### The Score Sheets

#### THE JUDGING FORM

The next pages tell how to fill out the form. It’s worth reading what each of the scoring lines means!

Judges will mark the same type of form for each kind of project (Science and Engineering) and for both the morning and afternoon judging rounds.
Each section below shows an excerpt of the judging form along with explanation on how to complete it. When interviewing the student(s), write the score digit(s) for each line item in the gray box to the item’s right. It is then easy to create the subtotals for each section.

**Aligning the Label**

The first action to perform for each judging session is to affix the label onto the judging form. The gray outline *precisely* matches the size of the label. Please do your best to get within a quarter inch or so. It’s easy to peel the label from the label sheet and then lay it down from bottom-to-top or left-to-right. Don’t try to smash it down all at once – you’ll wrinkle it (and then you’ll have to ask the runner for a new label).

**Marking Absent Projects & People**

Once the label is affixed, assess the presence of the project and student(s). Bubble the appropriate circle (as described above) if the project is absent, no students are present, or not all students are present. If no students (or project) are in evidence, return the form to a runner and enjoy a few minutes of browsing. If students are present, continue the interview.

These bubbles are directly to the right of the top of the assignment label:

- No Project
- No Student
- Incomplete Group

**Coloring the Bubbles**

Now it’s time to commence recording your scores. You can begin while the student or group presents their (optional) two-minute spiel. When you have chosen a score/evaluation, bubble in one of the elongated circles like this:

The fastest (and most effective, accurate) way to make such a pretty filled-in-oval is to use a number two pencil and circle around inside the oval until it is completely black.
Some folks like to get imaginative and use other marking methods. **These will not work.** Do not make your “bubbles” like these:

They include: an unfilled oval, a ‘X’, a check, an ‘X’ made with a superfine pen, a dot that is so small it can’t be detected, a poor erasure, and a blobby mark that is just plain wrong.

**Project Selection**

The Project Selection section assesses how well the project’s problem is defined, how original the project is, and the quality of the hypothesis or engineering goal.

<table>
<thead>
<tr>
<th>PROJECT SELECTION</th>
</tr>
</thead>
</table>
| ★ Problem is well-defined
| - Not so clear
| 2 Somewhat
| 3 Mostly
| 4 Clear
| ★ Originality of project
| - Unoriginal/copy
| 2 Tiny twist
| 4 Some novelty
| 6 New twist
| ★ Quality of hypothesis or Engineering Problem
| - Weak
| 2 Watered down
| 3 Strong
| 4 Very strong

**Appropriate to Age Group**

The bold star that precedes some questions is intended to be a reminder that the particular question should be evaluated in the context of the student’s level. Senior high school students, for instance, are probably geared up for dramatically greater challenge than sixth-graders. Over half the evaluation criteria are marked this way!

**Note that adults’ expectations of Science Fair projects generally run toward the very high side.** Try to evaluate projects relative to the levels displayed at this Fair.

**Judging Non-adults**

Many judging criteria are “starred” to indicate “judge appropriate to age group.” Bear in mind that none of the participants is a college graduate — they are fascinated and learning; they are not, generally, subject matter experts. Please have appropriately low expectations.

**Problem is Well-Defined**

Typical ways to evaluate ‘well-defined’ include: Could a layman understand what challenge is being tackled? How about a 10th grader?

**Originality of Project**

This question has a different weighting scale because it’s the one that really gets judges’ attention at subsequent Fairs. Unoriginality is easy to see . . . “completely original” is not. Use the scale as best you can to give your subjective viewpoint on just how original this project appears to be.

Note that some extremely complex laboratory or engineering projects might actually get a 0 here since they have nothing “new” or “novel” (at least to the student) to report as a result or as an approach. Combining well-known processes in a new way counts as “original” because the
combination is original even if the components are not. Likewise, “twists” or new insights contribute to originality. Low scores here for copying; higher scores for new ways to combine elements or new (at least unusual or uncommon) questions to ask/answer.

**Quality of Hypothesis/Problem**

All-in-all, is this a good hypothesis or a good engineering problem? Examine the hypothesis (or engineering problem statement) and determine (again, mostly subjectively) its strength. “Water appears to flow at room temperature” is a fairly weak hypothesis compared to “Transparent aluminum exhibits superior strength with temperature insensitivity”. A good hypothesis is non-obvious (to its poser!) and connotes a medium (and appropriate) amount of work to verify/test it.

**Project Design & Variables**

This section assesses the clarity and practicality (as far as completing the project goes) of the project’s design. It also assesses the relevance and evaluation techniques for the identified variables.

A project’s ‘variables’ include all those environmental and other influences on the outcome of a project. If plants are being grown with outdoor light, is the variability of seasonal sunshine taken into account? If one is measuring the speed of sound, are the variables of temperature, pressure, and humidity understood? Of course, this is always in the context of age group: one would not expect a sixth grader to know the subtleties of the relationship between humidity and the speed of sound in air.

Once measured, variables are used in a few ways:

- **Evaluation on an absolute scale** (“this car can climb a 45 degree slope”)
- **Comparison to similar measurements** (“this plant was third tallest in its group”; “this paper towel picked up more water than any other paper towel tested”)
- **Comparison to a control value** (“on average, rats taking the new drug lived 45 days longer than their counterparts who were administered a placebo”)

Appropriate to age group, students need to explain how all variables are/were measured, controlled, or constructively ignored (i.e., acknowledged but explicitly disclaimed to be outside the project’s purview). Note that students’ sophistication about variables is much lower in middle school than high school.

Science experiments compare two (or more) sources of data (e.g., a control plant grown outdoors and an experimental plant grown under a special light); engineering projects create a new device or process from scratch. Thus, engineering projects evaluate their results against absolute evaluation criteria (or specifications or another product/implementation).
rather than by comparing with some other instance in their project. This is reflected in the science vs. engineering versions of this section.

### PROJECT DESIGN & VARIABLES

| ★ Understandable research/project design | 0 - Not | 2 - Somewhat | 4 - Mostly | 6 - Crystal clear |
| ★ Practical & affordable | 0 - Not very | 2 - Somewhat | 4 - Very |
| ★ Relevant & appropriate variables chosen | 0 - No | 2 - Some | 4 - Many | 6 - Most |
| ★ How to evaluate variables | 0 - None Listed | 2 - Some evaluation | 4 - Most Listed | 6 - Complete |

**Understandable**

As presented by the display and the verbal discussion, is the project’s design easy to understand? Can it be explained without resorting to jargon or gibberish?

**Practical & affordable**

This question examines the project’s procedures (not its results). Does this project require the resources of IBM’s national research laboratory to complete? If so, it’s not affordable. Can the student, potentially working with a mentor, come to a reasonable conclusion? If so, then award full marks.

**Variables Chosen**

Are the variables in the experiment properly defined and laid out? Are controls included if appropriate?

**Evaluate Variables**

Is the procedure for evaluating the observation values for the variables well-explained? Feel free to ask about this or any other issue: the two minute introduction is for whetting appetites, not explaining the entire project.

### Materials/Procedure

This section assesses the cleverness of materials/equipment use and quality of the procedure.

| ★ Ingenuity/adaptation/practicality of equipment & materials | 0 - Standard | 2 - Some | 4 - Very clever |
| ★ Concise, reasoned procedure | 0 - Fair | 2 - Good | 4 - Excellent |

**Ingenuity**

How clever was the use of materials and equipment? Does the project display elegance in its use of materials and equipment?

**Concise, Reasoned Procedure**

Is the procedure well-done and professional? Is it executable?

### Data Measurements & Notebook

This section assesses the effectiveness of the data collection procedure and the project’s (usually hand-written) notebook. Key points include:

- Data must be observed and properly recorded
- Data should be observed multiple times to ensure reproducibility and mitigate observational errors.
- Notebooks must be created during experimentation, not afterward.

Ask to see their notebook; see if it looks like it was produced afterwards or during experimentation.
Judge Larry Mott feels notebooks are extremely important; some of his comments are paraphrased here:

Better notebooks extend for some months prior to the fair and include musings, data, mistakes, and show the flow of the project. I use the notebook during judging to gauge the quality of the projects. It is a direct indicator of the amount of work that went into the project and a dead giveaway if the student did not do the majority of the work.

Those who render inappropriate assistance do not think of doing a notebook if they are behind the curtains directing a project. I like to open the notebook at random and ask a specific question about an entry, an experimental result, an apparatus sketch, a data table, etc. The answers are very revealing indeed. Having the experimental data is just as essential as having the results.

Typed or neatly hand-written notebooks are likely to have been created after the project (a no-no). RBK adds that, of late, some students keep computer-generated notebooks as they go along. Finally, there are generally no erasures in proper notebooks, only lines through incorrect observations.

<table>
<thead>
<tr>
<th>DATA MEASUREMENTS &amp; NOTEBOOK</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Measurements valid &amp; recorded</strong></td>
</tr>
<tr>
<td>0 = Incomplete</td>
</tr>
<tr>
<td>2 Mostly</td>
</tr>
<tr>
<td>3 Valid &amp; Properly Recorded</td>
</tr>
<tr>
<td>4 &amp; Clear</td>
</tr>
<tr>
<td>5 &amp; Thorough</td>
</tr>
<tr>
<td><strong>Measurements appropriately replicated</strong></td>
</tr>
<tr>
<td>0 = Not/Can’t</td>
</tr>
<tr>
<td>2 A bit</td>
</tr>
<tr>
<td>3 Somewhat</td>
</tr>
<tr>
<td>4 Mostly</td>
</tr>
<tr>
<td>5 ≥ 3 Repro. measurements</td>
</tr>
<tr>
<td><strong>Quality notebook created throughout project’s execution</strong></td>
</tr>
<tr>
<td>0 = None/Created Late</td>
</tr>
<tr>
<td>2 &lt; 75%</td>
</tr>
<tr>
<td>3 75-90%</td>
</tr>
<tr>
<td>4 Mostly</td>
</tr>
<tr>
<td>5 Very thorough</td>
</tr>
</tbody>
</table>

**Data Valid & Properly Recorded**
This item assesses whether the data measurements were well-done in a professional manner. Check the data’s representation, the notebook, and the oral presentation to deduce if the data has been properly observed and recorded.

**Measurements Replicated**
Measurements (or samples, in some cases) need to be reproducible and replicated during experimentation to ensure that any given data reading is not a fluke. Use good judgment here, e.g.: measuring three successive gas-consumption runs of a new vehicle is just as good as measuring the height of three different plants grown under red light.

**Quality notebook created throughout project’s execution**
Check the notebook to make sure it was created during the full duration of the project. A notebook that is beautifully typeset and obviously re-done after the project gets no credit here (which is usually very counterintuitive to the student). No notebook means 0 points here. Typically, one asks the student to share their notebook so it can be examined.
Data Analysis

This section includes far more judgment than some of the previous ones. It assesses the analysis and statistics shown in the project.

### Data Analysis

<table>
<thead>
<tr>
<th>Data Limitations recognized (Instruments, accuracy, precision)</th>
<th>0 - No mention</th>
<th>2 - Fleeting recognition</th>
<th>3 - Good understanding</th>
<th>4 - Limitations listed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding of statistics, analysis, charts, and graphs</td>
<td>0 - Poor</td>
<td>2 - Low</td>
<td>3 - Medium</td>
<td>4 - High</td>
</tr>
<tr>
<td>Impression: Interpretation/Analysis</td>
<td>0 - Unsatisfactory</td>
<td>2 - OK</td>
<td>3 - Good</td>
<td>4 - Excellent</td>
</tr>
</tbody>
</table>

**Data Limitations Recognized**

The student needs to demonstrate an understanding of the limits of measurements (especially regarding precision and instruments’ limitations).

**Understanding Statistics and Graphics**

Too often, students get “help” from a well-meaning mentor who chooses statistics or tabular/graphical presentation techniques that are beyond the student’s abilities. This question asks for your judgment about that understanding. Query the student with relevant questions like, “Just what is a standard deviation?”

**Impression:**

Exercise your best judgment here to share your overall impression of the project’s interpretation and analysis of the collected data.

### Results

This section awards points for how well the project achieved the goals it set out to achieve.

<table>
<thead>
<tr>
<th>Results</th>
<th>0 - Minimal</th>
<th>2 - Adequate</th>
<th>3 - Mostly</th>
<th>4 - 95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete, thorough coverage</td>
<td>0 - Minimal</td>
<td>2 - Adequate</td>
<td>3 - Mostly</td>
<td>4 - 95%</td>
</tr>
<tr>
<td>Honest, logical results relevant to hypothesis/engineering plan</td>
<td>0 - Minimal</td>
<td>2 - Adequate</td>
<td>3 - Mostly</td>
<td>4 - 95%</td>
</tr>
<tr>
<td>Data/results justify conclusion</td>
<td>0 - Minimal</td>
<td>2 - Adequate</td>
<td>3 - Mostly</td>
<td>4 - 95%</td>
</tr>
</tbody>
</table>

**Complete, Thorough Coverage**

Does the experiment as executed meet the promise of the procedures and materials section?

**Honest, Logical Results Relevant to Hypothesis**

Examine the results to determine if they are honest, logical, and relate properly to the initial hypothesis. “Results” are very similar to “data”, though a certain amount of aggregation, summarizing, and/or statistics is implied.

**Data/results justify conclusion**

Does the totality of the data enable the experimenter(s) to reach the conclusion that is presented?

### Display and Exposition

The display is usually a backboard but can also be a more novel presentation. This section assesses the completeness and neatness of the display in addition to the overall verbal presentation of the project itself.
A complete backboard has all these items: purpose, hypothesis (or goal in the case of engineering projects), procedure(s), material/equipment listing (though this might appear in a notebook), data/results (potentially in summary form), analysis, and conclusion. Count them up (ignoring quality) and deduct points if some items are not present. Note, however, “that no particular credit should be given (or deducted) for purchased or borrowed equipment that is not part of the work of the student and serves only as a tool in the investigation” [8].

Neatness

Neatness is slightly distinguished from “professional”. A backboard can be extraordinarily well done with hand-lettering or very sloppy/messy with fancy computer-generated elements (though computer-generated elements do not generically incur much of a penalty). How does it look to you? Please don’t go into the chosen typeface for discussion; those sort of “taste” issues run long, deep, and with little helpful meaning.

Progression of Verbal Exposition

Students can choose any ordering and organization they wish for their presentation and in the way they answer your questions. What is your opinion of their introduction and responses?

Research

This section assesses whether the student performed background research about the project. The timing of the research is not discussed.

Most literature citations these days will be web-based. It is still relatively easy to count the reasonable citations (e.g., Readers Digest is rarely a good source of scientific information; neither are websites promoting a given agenda). If you are not familiar with some website, ask the student about it. “Is this from a company? a school? a library? How did you find this website?”

Sometimes students don’t understand that a reference to http://www.google.com is not as complete as it needs to be; they get less credit here.
Other approaches/theories
Is the contestant aware of how other people approached the problem they are solving?

Further research
Students are told to indicate further research for their project. This means that further research appears printed on their backboard or in their notes/notebooks – not solely presented verbally. Relevance to the current project is a plus.

Presentation/Interview
This section continues assessment of the verbal presentation and student’s general interactive responses to judges’ questions. While the interview is not strictly part of the project, it nevertheless has tremendous influence on the final results. This section is almost entirely subjective and enables a judge to award points for interview quality.

### Presentation/Interview

<table>
<thead>
<tr>
<th>Category</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proper focus on important ideas</td>
<td>0 - No focus, 1 - Poor, 2 - OK, 3 - Good, 5 - Great, 7 - Outstanding focus</td>
</tr>
<tr>
<td>Engagement level</td>
<td>0 - Little, 1 - Somewhat, 5 - Fully, 7 - Enthusiastic</td>
</tr>
</tbody>
</table>

**Proper Focus**
Does the student exhibit enough knowledge and skill to focus responses on the request information? Too often students will carry on at length in hopes of hitting a gold nugget somewhere in their information; this should not be rewarded.

**Engagement Level**
This question rewards those students whose attitude is one of strong participation or even enthusiastic passion.

Impressions
The newest section here is ‘Extemporaneous thinking ability’ which is really ‘Ability to think on one’s feet.’ This section was added in order to identify those students who have memorized their entire presentation along with answers to popular questions. Pick some random question about the project or its notebook to test this ability.

**For group projects, deduct points in each category where each member is not represented somewhat equally, e.g., if one person does all the talking.** Group projects are intended to be projects with equal contributors! The current guideline for two students is that the each student’s participation level needs to be between 1/3 and 2/3 of the total time. For three students, think more like 1/4 to 1/2 the time for each student (imbalance is a fact of life; we’re concerned with gross imbalances).

### Impressions

<table>
<thead>
<tr>
<th>Category</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extemporaneous thinking ability</td>
<td>0 - Poor, 2 - OK, 3 - Good, 4 - Very good, 5 - Excellent</td>
</tr>
<tr>
<td>General impressions of responses</td>
<td>0 - Poor, 2 - OK, 3 - Good, 4 - Very good, 5 - Excellent</td>
</tr>
<tr>
<td>General impression of knowledge</td>
<td>0 - Poor/bluffing, 2 - OK, 3 - Good, 4 - Very good, 5 - Expert</td>
</tr>
</tbody>
</table>

**Extemporaneous Thinking Ability**
Students talking from a script often cannot answer questions outside its strict bounds. This category (which judges both verbal communication skills and thinking on one’s feet) rewards those who have deep subject knowledge and can answer questions from that depth. Of course, these
students simply might not have a complete knowledge of their subject matter (since none of them has a Ph.D.), so the answer “I don’t know” is perfectly reasonable (and expected!) for challenging questions. This is a subjective category; please share your assessment.

General Impression of Responses
This is your opinion of the ‘big picture’ of the interview: did you have confidence in the student? Was the student informative, intelligent, polite, able to respond to questions, and forthcoming. This category depends entirely on your judgment. This is a subjective category; please share your assessment.

General Impression of Knowledge
Does the student have a clue what they are talking about? Any bluffing is an instant 0 in this category. This scoring item is also subjective.

Project as a Whole
This section contains subjective questions about the big picture of the project’s quality and organization in addition to oral and written description.

<table>
<thead>
<tr>
<th>PROJECT AS A WHOLE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project quality and depth</strong></td>
</tr>
<tr>
<td><strong>Organization</strong></td>
</tr>
<tr>
<td><strong>Special Innovation Level (Impression)</strong></td>
</tr>
<tr>
<td><strong>Overall challenge level</strong></td>
</tr>
<tr>
<td><strong>Percent work performed by student</strong></td>
</tr>
</tbody>
</table>

Project Quality and Depth
Is quality evident throughout the project? High marks for meticulous, in-depth work. As you examine the display and listen to the oral presentation, assess the project’s quality. Determine how far the student has really gone (e.g., measuring paper towel liquid absorption has less depth than creating a new substance harder than diamond).

Organization
High marks here for a methodical approach from the beginning to the end of the project. A slapdash project assembled the day before the Fair generally will earn low marks here.

Special Innovation Level
The PPRSF judging form assesses many items, but in the past it has failed to collect data on true innovation (e.g., nuclear fusion, cure for cancer, breeding of dinosaurs from DNA – truly unique, innovative, clever, somewhat useful projects).

This item asks you to tell us if the project is “special”. Probably 98% of the projects will be ‘Not Special’ or ‘Noticeable’. The other few (perhaps a couple in any given year? perhaps 0?) should score higher here. Don’t feel bad if you don’t see a cure-for-cancer level of project; they are very, very rare.
Overall Level of Challenge

Relative to the student’s current academic level, determine whether the work in the project was below, at, above, or even way above the student’s grade level. We record a letter here, since it’s not a question where scoring increases by a point or two. Most will be 95%-100%, but it’s important to mark those that aren’t.

Work Performed By Student

It is expected and encouraged that students solicit and receive help on their project. The key thing to evaluate is “what parts of the project that would have been appropriate for a student to perform were, in fact, implemented by the student?” Of course, if the majority of the project was something that a student could not implement (but was nevertheless implemented), then points should be deducted here. This item actually multiplies the total score by a number less than 1.0; be sure you mark it as best you can.

Often it’s easiest just to ask the exhibitor how much of the work he/she did and/or who helped them and how much. A quick follow-up, “Did you really build this electron microscope from scratch?” usually reveals the truth of the matter fairly quickly. Note that research supervision does not count against the “100% of the work” evaluation, nor does the occasional over-the-shoulder advice or even hands-on assistance – these are youngsters, not graduate students or industry-based engineers.

Completed Forms

Once you’ve completed marking the form (shortly after you finish interviewing the student), please turn the form to a runner (identified by a unique hat) who will convey it to scoring table. Please don’t forget to record the score on your assignment sheet.

The Judging Forms

The next two pages show the judging forms.
### PIKES PEAK REGIONAL SCIENCE FAIR 2017

<table>
<thead>
<tr>
<th><strong>PROJECT SELECTION</strong></th>
<th><strong>A</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>★ Problem is well-defined</td>
<td>- Not so clear  2 Somewhat  3 Mostly  4 Clear</td>
</tr>
<tr>
<td>★ Originality of project</td>
<td>- Unoriginal/copy  2 Tiny twist  4 Some novelty  6 New twist</td>
</tr>
<tr>
<td>★ Quality of hypothesis or Engineering Problem</td>
<td>- Weak  2 Watered down  3 Strong  4 Very strong</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>PROJECT DESIGN &amp; VARIABLES</strong></th>
<th><strong>B</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>★ Understandable research/ project design</td>
<td>- Not  2 Somewhat  4 Mostly  6 Crystal clear</td>
</tr>
<tr>
<td>★ Practical &amp; affordable</td>
<td>- Not very  2 Somewhat  3 Mostly  4 Very</td>
</tr>
<tr>
<td>★ Relevant &amp; appropriate variables chosen</td>
<td>- No  2 Some  3 Many  5 Most</td>
</tr>
<tr>
<td>★ How to evaluate variables</td>
<td>- None Listed  2 Some evaluation  4 Most Listed  6 Complete</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>MATERIALS/PROCEDURE</strong></th>
<th><strong>C</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>★ Ingenuity/adaptation/practicality of equipment &amp; materials</td>
<td>- Standard  2 Some  3 A lot  4 Very clever</td>
</tr>
<tr>
<td>★ Concise, reasoned procedure</td>
<td>- Fair  2 Good  3 Excellent</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>DATA MEASUREMENTS &amp; NOTEBOOK</strong></th>
<th><strong>D</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurements valid &amp; recorded</td>
<td>- Incomplete  2 Mostly  3 Valid &amp; Properly Recorded  4 &amp; Clear  5 &amp; Thorough</td>
</tr>
<tr>
<td>Measurements appropriately replicated</td>
<td>- Not/Can't  2 A bit  3 Somewhat  4 Mostly  6 ≥ 3 Repro. measurements</td>
</tr>
<tr>
<td>Quality notebook created throughout project’s execution</td>
<td>- None/ Created Late  2 &lt; 75%  3 75-90%  4 Mostly  5 Very thorough</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>DATA ANALYSIS</strong></th>
<th><strong>E</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>★ Data limitations recognized (Instruments, accuracy, precision)</td>
<td>- No mention  2 Fleeting recognition  3 Good understanding  4 Limitations listed</td>
</tr>
<tr>
<td>★ Understanding of statistics, analysis, charts, and graphs</td>
<td>- Poor  2 Low  3 Medium  4 High  5 Expert</td>
</tr>
<tr>
<td>★ Impression: Interpretation/Analysis</td>
<td>- Unsatisfactory  2 OK  3 Good  4 Excellent  5 Exceptional</td>
</tr>
</tbody>
</table>

**F**

- No Project
- No Student
- Incomplete group

15 circles to fill on this side

Write notes to back office judging staff inside this box

ALIGN LABEL ACCURATELY

2017 PPRSF Judging Handbook
# Pikes Peak Regional Science Fair 2017

**Appropriate to Age Group**

**RESULTS**
- Complete, thorough coverage: 0 = Minimal, 2 = Adequate, 3 = Mostly, 5 = ≥ 95%
- Honest, logical results relevant to hypothesis/engineering plan: 0 = Minimal, 2 = Adequate, 3 = Mostly, 4 = ≥ 95%
- Data/results justify conclusion: 0 = Minimal, 2 = Adequate, 3 = Mostly, 4 = ≥ 95%

**DISPLAY and EXPOSITION**
- Purpose, hypothesis, procedures, data/results, material/equipment (notebook), analysis, & conclusion neatness: 0 = Messy, 2 = OK, 3 = Good, 4 = Great, 6 = Stellar
- Progression of verbal exposition: 0 = Haphazard, 2 = Confused, 3 = Clear, 4 = Logical, 5 & 6 = Succinct

**RESEARCH**
- Cited authoritative appropriate literature: 0 = No, 2 = 1-2 Cites, 3 = 3-4 Cites, 4 = 5 or more cites
- Other approaches/theories: 0 = Little mention, 2 = Some knowledge, 3 = Good listing, 5 = Excellent
- Further research/development listed: 0 = Little, 2 = Adequate, 3 = Excellent

**PRESENTATION/INTERVIEW**
- Proper focus on important ideas: 0 = No focus, 3 = Good focus, 5 = Great focus, 7 = Outstanding focus
- Engagement level: 0 = Little, 3 = Somewhat, 5 = Fully, 7 = Enthusiastic

**IMPRESSIONS**
- Extemporaneous thinking ability: 0 = Poor, 2 = OK, 3 = Good, 4 = Very good, 5 = Excellent
- General impressions of responses: 0 = Poor, 2 = OK, 3 = Good, 4 = Very good, 5 = Excellent
- General impression of knowledge: 0 = Poor/bluffing, 2 = OK, 3 = Good, 4 = Very good, 5 = Expert

**PROJECT AS A WHOLE**
- Project quality and depth: 0 = Average, 3 = Good, 5 = Excellent, 7 = Superior
- Organization: 0 = Average, 3 = Good, 5 = Very organized, 7 = Superior organization
- Special Innovation Level (Impression): 0 = Not Special, 3 = Noticeable, 5 = Unique, 7 = New & special
- Overall challenge level: 0 = Below grade, 3 = Above grade, 5 = Way above grade
- Percent work performed by student: 0 = <80%, 3 = 80-84%, 5 = 85-89%, 7 = 90-94%, 9 = 95-100%

**JUDGING FLOW OVERVIEW**
- Introductions
- Student generally has three minute 'speech': don't let them go past 3 mins
- Interview student to determine scores for this form; bubble the point values
- At four minute warning: complete score sheet and feedback sheet
- Give feedback sheet to student
- Double check this sheet and give to runner

19 circles to fill on this side

Return this form to a runner when complete.
Leaving early

If you as a judge must leave early (any time before your final project is judged), please turn in your schedule at the scoring table in the basement so that we can handle your absence.

Feedback Forms

Judges are the professional authority for the competitors. Please be sure you fill that role properly.

All rounds include written feedback to students given on very free-form full sheets of paper. In the top third, circle a few (one? two? three?) of the areas in which the student’s project excelled.

<table>
<thead>
<tr>
<th>PROJ ID</th>
<th>JUDGE ID</th>
</tr>
</thead>
</table>

JUDGING FEEDBACK
PIKES PEAK REGIONAL SCIENCE FAIR 2017

FAVORITE JUDGING AREAS (Circle as many as appropriate)

- Project Selection
- Project Design
- Variable selection & Evaluation
- Procedure
- Data Measurements
- Notebook
- Data Analysis
- Results
- Backboard
- Verbal Presentation

GOOD THINGS ABOUT THIS PROJECT:

CHALLENGE FOR THE FUTURE:

In the next area, please try to pick two or three items to emphasize as positive feedback (even if science isn’t in their future, they may well become a politician voting on science!):

- I liked _______ best about your project
- You did a great job on ____________
- _______ was really well done
- You did really well on ____________ and ____________

Some judges put a header (e.g., “Best parts of your project”) and list the parts they enjoyed below that.

It is often appropriate to offer a suggestion or idea for improvement; it is not a requirement. Don’t hesitate to do so – but please confine negative feedback to one thought per judging session. Please avoid nasty words (i.e., don’t be like the mean judge on American Idol). Suggestions could be couched like “If you had more time, you might have _____” or “If you
wished to expand on this, you might ____” or even “The best way to improve your score for next time would be ____”.

Try to leave them with something concrete. Avoid: “Your analysis was just not up to par.” in favor of “Calculating the mean and variance for the distribution of your results would have strengthened your analysis.”

Feedback will in all likelihood be shared with both parents and teachers; please write feedback so that it is favorably received by all (and unlikely to generate litigation).

**Chairs**

If you prefer sitting while judging, don’t hesitate to ask the student to share the chair.

**Parallel Judging**

Both “special awards” and “backup” judges are judging the contestants, potentially at the same time as we (the Fair Award judges) are. The backup judges will work with us on the Grand Award winners.

**MULTIPLE JUDGES AT A PROJECT**

Category judges (like you) have a certain “priority” in judging. You always get to judge a project (potentially with another category judge) on the provided schedule, even if other judges are there. Feel free to watch or to interrupt and explain that your schedule is immutable.

**Avoid Arguing**

This is really hard! The students who are deeply invested in their projects often have extremely strongly held beliefs that they do not wish to justify or change. Besides the obvious actions to avoid (like being patronizing), please avoid “arguing” with the competitor. If they are sticking by an erroneous assumption or argument, mark the scoresheet and proceed after potentially probing a tiny bit.

Why? Judges don’t have enough time; everyone gets impatient; and a stubborn student will just walk away frustrated. None of these achieves our goals.

**Safety**

Before the judging starts, the PPRSf Safety Team checks all exhibits to make sure they conform to International Science Fair standards. If you as a judge find something questionable, please notify a runner to report this to the scoring table immediately (with the project ID, of course). Proceed to judge the project normally.

**Discretion**

Please ensure that any discussions you have are properly private. Students (competitors) are everywhere – even in bathrooms. Please be discreet. This again caused problems at a recent fair!
Sensitivity/Harassment

Please avoid harassment and discrimination/prejudice in its myriad forms: age, race, color, national origin, ancestry, religion, gender, gestures, physical contact, and disabilities (including blindness and deafness). Please avoid improper remarks, gestures, physical contact, anything that might be construed even remotely as offensive.

Judge This Year’s Research

Note that only research conducted in the last 12 months is to be judged. Previous efforts can be discussed briefly but should not form a core of this year’s project. Request a runner to fetch the head judge if you think a project does not contain enough current research.

Feedback no-no’s

Please do not foretell or predict results. A casual, offhand remark like, “I’m sure you’ll win a prize,” makes headaches for the staff later when the student’s parents ask where the prize is. Students write letters; teachers write letters; it gets quite painful. “Great project; I hope you do well,” is fine. “This is fantastic; I’m sure you’ll go to the State Science Fair,” can ruin a complete science fair for the head judge who must undo the problem.

Sample Questions

To get your brain thinking on the sorts of questions to stimulate discussion with the contestant, here are some queries you might consider.

Before we get to the questions, though, let’s not ask: “Why is this project important to you?” I don’t see how that helps.

• You can always ask for the definition of a (presumably technical) word the contestant uses.
• In response to a question, contestant says, “I don’t know.” No problem. Your reply: “How would you figure it out?”
• When it’s time to probe peripheral knowledge, please preface your ever-more-challenging questions with: “I’ve got some questions slightly peripheral to your presentation, don’t be bothered if they are out of your area of expertise” or some students will get extremely nervous. Remember: even a second grader can corner the smartest people just by repeatedly asking, “Why is that?”
• Where did you get the idea for this project?
• What did you enjoy most?
• What problems arose during your investigation?
• How did you overcome them?
• Do your results indicate further study is needed?
• What is the purpose/objective of your study?
• What are some previous studies?
• What are the possible sources of error?
• How accurate are your measurements?
• What is/are your controls?
• Why did you do the statistical analysis the way you did? What does it mean?
• How many times did you repeat your measurements?
• Over what time period did you conduct your study?
• On what did you base your conclusions?
• Are there are any other approaches you might have taken to your research?
• What instruments did you use for your measurements?
• Tell me about the equipment you constructed yourself.
• What would you do differently if you were doing this again?
• Do you think you could continue development of this project?

Acknowledgments
Several folks dramatically improved the quality of this document. Thanks to Bruce Erickson, James Hardy, and Richard Painter. Any errors that remain, of course, are mine.

References
[1] Vancouver Island Regional Science Fair
[2] Minnesota Academy of Science
[4] Kern County Science Fair
[5] Louisiana Region VIII Science Fair
[7] Discovery Channel (discoveryschool.com)