Inquiry Grading Rubric

Student:_____ Evaluator:_____

The points that can be deducted from each category add to much more than 100 because scientific work can be rendered invalid by poor performance in any of these areas. Employ the rubric by deducting points in areas where improvement is needed. Unsafe practices or plagiarism lead immediately to a failing grade. Please note that no rubric or checklist can fully capture the full range of strengths and difficulties that describe independent inquiries. This rubric provides a guide to help you identify common misconceptions and errors, but cannot fully cover all cases. For example, if a student were to obtain a genuinely new research result of some importance, he or she might be granted some leniency in categories related to presentation.

Deduct up to			**Deduct nothing from categories that are not applicable**
	Idea		
⌊100	*Safety and Ethics*		***Inquiry is conducted in accord with safe laboratory practice, and treats human subjects in ethical manner.***
		100	Inquiry has been conducted in an unsafe manner or involves illegal or unethical elements. Animals have been mistreated. Safety of human participants has been jeopardized. Example: Student wants to investigate whether girlfriend's energy level varies as he varies the dosage of her prescription medication.
		10	Inquiry appears to have been conducted in safe and appropriate manner, but documentation is missing or some questions about safe practice are not addressed.
		5	Inquiry appears to have been conducted in safe and appropriate manner, but documentation is incomplete and some questions about safe practice are not fully resolved.
		0	Student is aware of all issues surrounding ethics and safety of experiment and addresses them fully in written report. Animals and humans are treated in safe manner, following relevant guidelines. Student has obtained all necessary release forms, and completed all necessary safety training.
⌊20	*Motivation and time*		***Student is engaged by question and progress could reasonably be expected in time allotted.***
		20	Student appears to have put no effort into project and displays no interest in outcome. Or student has settled upon project that could not possibly have been completed in limited time availble. Example: in 4-week project, student wants to study how size of tomatoes grown from seeds depends upon temperature. Or student spends far too little time on project. Example: student has six weeks to complete project and puts a total of one day's work into it.
		10	Student appears to have put marginal effort into project and displays marginal interest in outcome, or expectations concerning time required for project were very unrealistic, or student spends too little time on project
		5	Student has put effort into project but does not appear to be interested in outcome; or, project has suffered because of poor use of time.
		2	Student has worked hard on project and indicates interest in outcome and used time reasonably well.
		0	Student has worked very hard on project, displays great interest in outcome, and has used time very well.
	Experimental Design		
⌊20	*Calibration*		***Measuring instrument has been configured to take meaningful data.***
		20	Instrument provides meaningless numbers due to improper usage or lack of calibration. Example: sensors that only work when placed vertically are used in horizontal position. Example: Objects weighing more than 500gm are placed on scale giving 500 gm as maximum reading and all claimed to weigh the same. Example: 400 Hz vibrations are measured with sensor taking data at 10 Hz.
		10	Accuracy of experiment is greatly reduced because of insufficient attention to calibration, range, and precision of instrument.
		5	Instrument calibrated correctly on some occasions but not on others.
		2	Some results suffer reduced accuracy because of lack of attention to calibration and range.
		0	Instrument is correctly employed and calibrated at all times.
⌊20	*Error*		***Possible sources of random and systematic error have been identified, and actions have been taken to reduce them when possible.***

Deduct up to

Deduct nothing from categories that are not applicable

20 One or more factors that have not been considered properly invalidate results. Example: measurement of the time needed for a ball to fall is dominated by human reaction time with a stopwatch. Example: student conducts a survey on whether people prefer to walk or drive by standing on a sidewalk and surveying those who walk by. Example: Prediction that Dewey would beat Truman in 1948 presidential election was due to conducting telephone poll in days when wealthy were more likely to have phones.

10 Some results invalid or very inaccurate because of factors or biases not considered. Example: a wooden block sliding down a wooden ramp is analyzed without taking friction into account. Example: survey of how typical UT students feel about math courses is conducted by surveying people in physics/math/astronomy building.

5 Some results are not accurate or trustworthy because of factors not taken into account. Example: A measurement of the weight of air in a balloon does not compensate for weight of rubber balloon itself. Example: weight measurements of small object on precise scale are taken quickly while other students bang closet doors near scale.

2 Some results are questionable because of factors not taken into account

0 Possible sources of systematic error are understood, and have been removed to the extent possible.

| 10 |

Effects of random error are reduced to acceptable level through appropriate number of samples.

10 Number of measurements is insufficient to support desired conclusions, and there is no evidence that this difficulty is appreciated. Comment: In the first stages of an experiment, there is usually little choice but to conduct a small but arbitrary number of measurements to get one's bearings. The issue is whether one learns well from this experience in the later phases of the experiment. Example: Survey of whether UT students want to build new student union is conducted by polling 5 people. Example: Effect of vinegar on plant growth is conducted with two plants; one with some vinegar in soil, other without.

5 Number of measurements hampers ability of student to arrive at conclusions. Example: Effect of vinegar on plant growth is conducted with five plants with different levels of vinegar, but no two plants with the same amount of vinegar, providing no estimate of the natural fluctuations in height from one plant to another. Example: student surveys 30 people (intrinsic uncertainty on order of 20%) trying to learn about presidential race known to be quite close.

2 Number of measurements is adequate to support desired conclusions, but appears to have been arrived at in completely arbitrary way. Example: To see whether a scale gives reproducible results, student weighs penny on scale 100 times, even though the measurement never differs by even one part in 1000 for any two trials.

0 The formula $s_{\bar{x}}=s/\sqrt{N}$ or other appropriate equation is used to calculate number of measurements to reach desired accuracy once preliminary data have been obtained, and appropriate quantities of data have been obtained.

| 10 | *Variables*

Experiment is carefully designed to vary control, measure response, and keep other variables constant.

10 Experiment is invalid because of failure to identify clearly quantities held fixed and quantities allowed to vary. Important variables vary from trial to trial and are not even recorded. Example: Student wants to know how growth of plant depends upon sunlight, but keeps plant outside and does not record temperature or rainfall.

5 Validity of experiment is somewhat reduced because of failure to identify clearly quantities held fixed and quantities allowed to vary. Example: student wants to see how manageability of hair depends upon meals eaten, but eats different foods each day the experiment is being conducted. Example: Student records number of people walking past his house between 9 and 10 each morning on 10 consecutive days, but without recording anything about weather or even day of the week.

2 Quantities to be varied and quantities to be held fixed are clearly identified, but the number of quantities being varied is too great for a persuasive experiment to be possible in the time allotted.

0 Student has decided to vary a limited number of quantities, and measure a limited number of quantities, and has thought carefully about how to keep everything else constant.

Analysis

| 10 | *Graphs*

Displays data in graphical form, including histograms or functional relations as appropriate.

Deduct up to		**Deduct nothing from categories that are not applicable**
	10	Large quantities of data have been taken, and are either reported in large tables of data or not at all, and no graphs are presented
	5	Some important data that should have been represented in graphical form have not been.
	2	Graphs have been prepared when necessary, but some are confusing or improperly prepared.
	0	Makes use of appropriately constructed graphs whenever needed in order to explain results.
15		***Indicates error bars on measurements as appropriate.***
	5	There were repeated trials for various measurements, but no error bars have been computed or recorded, or else they have been computed incorrectly.
	0	The standard error has been computed for all repeated trials and recorded on plots as error bars.
15		***All axes are labeled and units clearly indicated.***
	5	Axes are not labeled
	0	Axes are labeled
15	*Statistics*	***Computes means and standard errors for measured variables.***
	5	Performs repeated trials, but does not compute the average or other measure of central tendency, or interprets them incorrectly.
	0	Calculates, reports, and correctly interprets means and standard errors.
120		***Makes appropriate use of statistics.***
	20	Has neither null hypothesis nor testable question, and arrives at conclusions without any statistical arguments.
	10	Has testable question, but fails to use statistics when interpreting data: Example: calculates means of different quantities, and concludes that one is larger than the other without considering whether the difference could be due purely to chance.
	5	Attempts to use statistics to understand significance of outcomes, but makes technical errors. Example: uses χ^2 test appropriate for integer samples on continuous data.
	0	Employs statistics to establish significance of results. Example: uses the standard error associated with means to decide whether the difference between means is significant. In a first pass, this could be performed by looking at graphs, and next if needed by use of Z or t tests. In experiments with complex design, a more sophisticated test such as ANOVA may be appropriate.
120	*Modeling*	***Constructs simple predictive relations, ranging from fits with simple functions to recursion relations or differential equations, analyzes their consequences in programs such as Excel, and compares with data.***
	20	Experiment involves quantities that vary in regular fashion in time or space, but student makes no attempt to construct predictive model, not even one employing just elementary functions. Level of predictive modeling that can be expected depends upon mathematical sophistication. Many apparently simple situations, such as objects acted upon by friction, may require use of calculus.
	10	Constructs predictive model that is completely inappropriate. Example: blindly clicks on a randomly chosen regression function in Excel and presents the formula. Example: uses addition in a formula where multiplication is appropriate.
	5	Student makes some technical errors in construction of predictive relation. Example: presents adequate linear fit in case where data are clearly fit by exponential function.
	0	Constructs correct predictive relations, ranging from simple formulas that might be based upon dimensional analysis, up to and including recursion relations or differential equations, analyzes their consequences in programs such as Excel, and compares with data. Some classic patterns that should be familiar to almost everyone include exponential growth and decay in their many manifestations.
	Sources	
110	*Literature*	***Makes use of research literature to answer questions outside scope of project as needed.***
	10	Asks questions that cannot possibly be answered by isolated inquiry, and makes no attempt to learn any background from books or articles. Performs no searches in case where they are needed and appropriate
	5	Employs sources to provide background to inquiry, but chooses inappropriate or unreliable sources. Example: relies exclusively on rapid search with Google or other general search engine and obtains inappropriate materials. Articles that have passed through peer review are generally much more reliable than websites. Many websites contain information from people without special knowledge, that have not been checked by those who have, and cannot be trusted.

Deduct up to **Deduct nothing from categories that are not applicable**

0 Makes use of books and articles as inquiry progresses to deepen understanding. Comment: in Moore method, use of external sources is heavily discouraged, and students should develop all mathematics for themselves. If an instructor has developed such a context, there should not be a penalty for failure to consult sources. Even in research areas that are highly developed, there can be times when it is extremely profitable for researchers to try to think matters through completely on their own without consulting sources. Different people have different styles. However, if experimental data are needed for an inquiry, and if gathering them is beyond one's resources, then one really must look them up.

Written Presentation

| 20 *Overall quality* ***Clearly written with correct grammar and spelling.***

20 Inquiry report is carelessly written in very poor English, and is impossible to understand.
10 Inquiry report is carelessly written in very poor English, and is difficult to understand.
5 Inquiry report is written in poor English that detracts from its quality.
2 Inquiry report is by and large well written, but contains occasional errors in grammar or spelling that detract from its quality.
0 Inquiry report is well written in clear, grammatically correct, and engaging English.

| 10 *Abstract* ***Clearly explains purpose of project and summarizes main conclusions.***

10 Report does not contain an abstract.
5 Abstract is taken verbatim from proposal and is written in future tense without any description of results.
0 Abstract allows a broad audience to learn main conclusions from project by reading a few sentences.

| 10 *Design* ***Design of experiment or survey is clearly explained with appropriate mixture of words and diagrams.***

10 There is no description of design or experimental procedure. In surveys, there is no description of large population sample is supposed to represent.
5 The procedure used in the experiment is described but is difficult to understand and would be hard to reproduce. In surveyes, description of the large population the sample should represent is vague and not completely convincing.
0 Report contains a detailed description of the procedure, providing enough information that someone else could reproduce the experiment, and also providing guidance about attempts that did not work, and explaining why the procedure employed was successful. For surveys, report carefully describes large population the sample is supposed to represent, and explains steps taken to make the sample representative of the whole.

| 100 *Literature* ***Provides citation for all sources employed in study and explains their significance***

100 Plagiarizes report
20 Uses unattributed material from internet or other sources.
10 Makes use of background sources and places material in own words, but without attribution.
2 Makes use of inappropriate sources, although with correct attribution.
0 Uses appropriate sources as needed. Uses quotations up to 50 words, with attribution. Puts longer passages into own words, again providing citation.

| 10 ***Engages in critical analysis of sources.***

10 In areas where controversy still exists, simply reports what one side or the other says with no discussion. Example: A phenomenon called "cold fusion" was announced to the media in the mid 1980's. The phenomena could not be reproduced in other laboratories, and most articles in peer–reviewed journals say they do not exist. Some of the scientists who found the phenomenon started their own journals so they could publish, but these have no credibility. By contrast, "high–temperature superconductivity," which was found a bit earlier, was rapidly reproduced at many laboratories, and has been a standard scientific topic ever since.
5 Acknowledges differing points of view within the scientific community, but overlooks or misrepresents some important points of view.
0 Is aware of and acknowledges differing points of view within the scientific community, and uses reasoned arguments to explain why he or she has adopted a particular view. Example: Most environmental scientists believe that the planet is warming, and that steps should be taken to slow the production of greenhouse gases. However, the position is not universally held, and it would be legitimate for a student to explain why he doubts the majority view, and to perform an inquiry to check claims that are customarily made

Deduct up to **Deduct nothing from categories that are not applicable**

|10	*Collaborators*	***Acknowledges all collaborators on project and explains their role***
	10	Does not mention collaborators in written report.
	5	Mentions name of collaborator, but not role in project
	0	Acknowledges all collaborators on project and explains their role
|10	*Analysis*	***Thoughts leading to analysis of data are clearly explained, with all graphs and computations described in words.***
	10	Graphs or equations are presented with no explanation.
	5	Graphs or equations are presented with confusing or incomplete explanations.
	0	Clear verbal explanations accompany all graphs and equations, explaining their significance and how they were obtained.
|10	*Conclusions*	***Consequences of study are clearly communicated, neither generalizing too much, nor omitting important findings.***
	10	Report terminates without conclusions.
	5	Concludes with statements that do not honestly reflect conclusions that could be reached from work described in the body of the presentation. Sometimes, these may represent wishful thinking, or a desire to impress the teacher.
	0	Thoughtfully summarizes the main results, acknowledging both strengths and weaknesses of what has been accomplished, and indicating new things that might be interesting in the future.
|100	***Total Written***	

Oral Presentation

|50	*Presentation Style*	***Speaks clearly and at audible volume, engages audience, employs visible font sizes, and uses graphical materials or live demonstrations whenever possible to illustrate ideas.***
	50	Presentation is impossible for audience to understand because of poor use of spoken language and visual tools.
	20	Presentation is very difficult for audience to understand because of poor use of spoken and visual tools.
	10	Presentation is understandable, but either the written words and graphics or spoken presentation need improvement. Example: many slides use fonts too small for many in the audience to see. Example: talk is presented too softly for many in the audience to hear, or throughout seems tentative and uncertain.
	5	Presentation is effective, but could be improved in places by more effective speaking style, or better use of written words and graphics. Example: some slides have written material written in small fonts that are difficult for some to see. Example: speaker does not always speak loud enough for whole audience easily to hear. Example: everything speaker says is written on slides, and speaker simply reads slides to audience.
	0	Presentation is easy for all audience members to hear and understand, it is engaging, and the presentation makes effective use of spoken words and visual materials to convey understanding.
|10	*Introduction*	***Describes motivation for project.***
	10	There is no introduction to the project. Plunges into details of project with no attempt to engage audience.
	5	Explains why project is interesting, and attempts to involve audience, but introduction needs substantial improvement. Example: speaker refers to advanced concepts in biology, not recognizing that half the audience consists in math majors.
	0	Clearly explains why project is interesting, and involves audience.
|10	*Background*	***Provides clear summary of relevant background knowledge.***
	10	Does not describe any relevant background knowledge
	5	Uses technical terms unknown to the audience with no explanation, and refers to theories and ideas that are never explained.
	0	Given time constraints, uses words and pictures to teach as much relevant background as feasible. Defines all technical words that are used later.
|10	*Design*	***Describes project design, explaining major choices, using diagrams and illustrations.***
	10	Does not describe project design.
	5	Makes vague reference to procedure, without explaining to anyone how goals were reached.

Deduct up to		**Deduct nothing from categories that are not applicable**
		0 Clearly describes experimental procedure, making good use of words and images.
|10	*Results and Data*	***Presents main results***
		10 Does not present main results.
		5 Presents main results, but they are very difficult to understand. Example: presents screens full of unreadable charts full of numbers
		0 Clearly and accurately represents main conclusions arrived at in study. Concisely conveys statistical certainty with which results were reached. In most cases, these goals are best met by presenting results in graphical form with error bars, and summarizing them well in spoken and written words.
|10	*Conclusions*:	***Summarizes findings***
		10 Comes to a halt without concluding statements.
		5 Closing points are confusing.
		0 Closes with a clear statement of the main points to remember.
|100	***Total Oral***	