Generic Rubric for Summer Physics

St. Ignatius College Preparatory

Assessment	**4.0 / A** **Masterful, engaged, able to generate new ideas**	**3.0 / B** **Proficient, skilled, competent**	**2.0 / C** **Possessing of some skill; still practicing**	**1.0 / D to 0.0 / F** **Not yet proficient or unable to assess**
Written exam or quiz problem; oral examination	**Outstanding qualitative and quantitative work** woven together to present a coherent solution **suitable for use as a key** for next year's class	**Correctly worked** solution demonstrating right physical reasoning in an understandable way; any **errors are relatively minor**	Incomplete or incorrect solution demonstrating **some insight and some skill** with the problem; student does not yet skillfully use *all* of the necessary tools	Incomplete or incorrect solution **requiring review** of fundamental concepts and methods; alternatively, instructor is **unable to assess** work
Project involving fabrication, performance, or demonstration	Work product **transcends or exceeds** expectations in some insightful and unique way	Work product **completed and demonstrated** as required	Work product **does not meet project requirements**; however, student has demonstrated **some progress** and understanding	Work product is **not complete or only partially complete**; alternatively, instructor is **unable to assess** work
Written essay, research paper, or laboratory	Written work **generates a new idea** that goes beyond the expectations of the assignment; student demonstrates qualitative and quantitative **fluency in the scientific method**	Writing meets **grade-level standards**; equations, calculations, and prose are combined in a natural way; the work is **grounded in the scientific method**	Writing does not meet **grade-level standards**; or, student work is **missing** one or more core components of the **scientific method**	Written work is **not complete or only partially complete**; work is not scientific; alternatively, instructor is **unable to assess** work
Consequence	Student may be granted an **exemption** from further assessment in this topic; work may be **used as a key**, posted to the Hall of Fame, and/or noted in a letter of recommendation	**None**: student has met the teacher's minimum expectations for this topic	Student is required to **consult an example** of excellent work (or key) and use it to write a short note explaining and/or **correcting their own work**, to be turned in promptly	Student is required to demonstrate that they have **met in person with a course instructor or TA** to review and relearn this material; instructor or TA may assign **additional required work**

The Scientific Method

St. Ignatius College Preparatory

1. A theory is useful in as far as it has **predictive power** and **explanatory power**. The discerning questions are these: Does the theory predict the behavior of the real world? Does the theory help us to understand things we didn't understand previously? If the answer to either of these questions is no, the theory must be amended. *Example*: if my physics theory predicts that a feather will accelerate towards the ground at 9.8 m/s^2, but I measure the acceleration to be 7.0 m/s^2 +/- 0.5 m/s^2, then my theory is wrong and I must revisit it. My new theory might take into account the force of air resistance, which would both better predict the measured acceleration *and* better explain why the acceleration is less than I thought before.

2. Your **methodology** must be clear and reliable. Others should be able to understand and repeat your work just based on your description, and arrive at the same conclusions you did. There are no hidden data or secret techniques. *Example*: if, when investigating the neural responses of a primate, I kept it sedated, I must report this. Even my research competitors should be able to figure out exactly how my experiment was performed. Otherwise, why should they trust my results?

3. Experiments must be **controlled**; that is, the experimenter must be sure that his or her hypothesis or theory can be uniquely tested. No conclusions can be drawn in the comparison of two results unless all other relevant influences are understood and controlled for. *Example:* if it is my hypothesis that breast cancer is linked to a certain gene, I might use the genetic data and medical history of identical twins separated at birth so that I do not confuse environmental factors with hereditary ones. Experiments are credible only as far as they cleanly separate variables from controls.

4. Experimental **measurements and observations** must be *clear* and *truthful*. To have any meaning, measurements must be accompanied by estimates of the corresponding systematic and statistical errors. *Example*: if I measure the volume of liquid in a glass of water to be 350 ml, and I am confident of this measurement to ± 1 ml accuracy, I must state the measurement as 350 ml ± 1 ml. Likewise, if I state a prediction, I must also state the accuracy of the prediction. Thus, I might argue that there is a 95% probability that between 5 and 10 ml of liquid will evaporate by morning.

5. Your theory must be **falsifiable.** In the face of a conflict between a theory and a well-designed experiment, the experiment is to be trusted, and the theory must be amended or discarded. Claims made that cannot be tested in a controlled way are outside of science. *Example:* you make a controlled experiment that shows that a certain "psychic" is not able to predict the playing card you were holding; the psychic claims that the experiment itself "interfered" with his psychic power, so the experiment was meaningless. The psychic's claims are therefore not scientific.

6. The scientific method is grounded in the notion of **cause-and-effect**. *Example:* you fear that electric fields produced by cell phones are causing brain tumors; to support your hypothesis, you must not only demonstrate a *correlation* between cell phone use and disease, you must also provide a *causal* explanation of *how* the field can physiologically generate a tumor. Correlation does not imply causation.

7. The more often a theory is tested successfully, the more credibility it has. Still, ultimately, all theories are **conditional**. It is understood that they may someday be replaced by a more complete theory. Refuted theories might still be **useful** as long as we restrict their use to situations where they have been successfully tested. *Example:* Newton's theory of gravity was replaced by Einstein's theory of gravity (General Relativity). Einstein's theory makes better predictions in a wider set of circumstances *and* has more explanatory power. However, Newton's theory is mathematically simpler, and works just fine for most situations. Rocket scientists are happy to use Newton's theory when computing spacecraft trajectories.