Projects

Below is a set of projects that you can undertake—an experiment you can do, or topics to research. They also have methods you can use and questions you can answer.

1. **Sundial.** Sundials have been used for centuries, perhaps millennia, to tell time. In this project, you research how to build one, and perhaps build one (it just takes a stick). This is a good team project, so you may want to choose team members, assign roles, set deadlines, and have good back-and-forth discussions on how to pull off this project. You can increase or limit the scope of the questions below depending on time and team size.

   Some questions for you:

   a. How were sundials used in history? Can you come up with some quotes from literature about sundials?

   b. The most concise description of a sundial is that it is a stick and its shadow points due south at noon. Why does this work? Explain the astronomy that makes the dial work.

   c. We say "noon" in part (b), but what is meant exactly by "noon"? Would a highly exact clock, such as the one on a cell phone, necessarily agree with what the shadow says? Explain to your classmates the different ways "noon" could be measured at your school.

   d. Either create a simple sundial or, as a thought experiment, imagine one being built at your school. What factors about its location do you need to know so that its measurement of noon, and one as reported by, say, a cell phone, agree?

   e. What is an "analemma," and how does it relate to the construction of a sundial? Again, explain the astronomy and geometry behind its use.

   f. Optional: Explain the functioning of a horizontal sundial. What benefits does it offer?

   When presenting this information, use technically accurate words, and explain any (such as *analemma*) that your audience is likely not to know. Recognize that your audience is taking a physics class, not an astronomy class, so explain the fundamentals of astronomy as needed. Recognize that your audience might be biased to more portable time-telling devices, so try to engender some enthusiasm about the simplicity of the sundial approach. Plan and organize your presentation, using multiple drafts as necessary, and perhaps post some work on the Internet for feedback even before the presentation. Consult a variety of resources on this project—texts, sources on the Internet, and so on. Assess the accuracy and knowledge of the sources you use. When presenting, have a consistent structure so that relationships are clear and the presentation flows. Vary your syntax and sentence length, and use other media as appropriate (pictures of sundials, and even a simulation of how one works).

2. **Research and explain quantum entanglement.** The accepted theory is that the speed of light in a vacuum is a maximum. How does quantum entanglement challenge that theory?

   Quantum entanglement is a relatively new idea. Explain the arguments and counter-arguments about its existence.

   - Cite specific textual references that describe its existence. Be clear about any gaps or inconsistencies in the information presented.
   - Find information about the topic in scientific journals: How are journals structured into categories or hierarchies, and how is that structure used to convey information? Compare how the idea is presented in a scientific journal, a newspaper article, and a web article.
   - Using sources of information on quantum entanglement, determine their central idea and summarize complex ideas by paraphrasing them into simpler but accurate terms. Make sure you understand key terms, symbols, and so on, that are related to this topic.
   - Consider the author's reason for writing an article: One author may be interested in the commercial applications of the concept, while another might be interested in how it affects current scientific theory. Identify any issues that the author considers unresolved.
   - Evaluate the hypotheses, data, analyses, and conclusions on this topic. Search for the most recent data and confirm or challenge conclusions with other sources of information.
   - Combine information from a range of sources into a coherent understanding of quantum entanglement, resolving conflicting information when possible.

3. **Explain why astrology is considered a "pseudo-science,"** one that cannot be validated by observations and scientific consensus.

   Create a presentation that has empathy for those who do believe in astrology, and create a presentation that is appropriate for non-scientists. Evaluate the hypotheses, data, and analysis of this field with relevant scientific data. Consider the author's reason for writing material on astrology.

4. **Document the role of women in physics and in related fields.** The movie *Hidden Figures* is an excellent example of exploring the vital role women played in the formulation of calculations required for space flight.

   You should:

   - Use varied sources of information (books, articles, speeches, videos).
   - Determine an organizational approach for your presentation (by year? by area of science?).
   - Write/create multiple drafts.
   - This is a project that can be short-term, or a longer-term project. For instance, as you move through various physics topics (such as electricity and magnetism), you can research women's contribution in that field.

- Use varied media in your presentation—pictures, videos, speeches, and so on. After all, Hollywood could make a movie about it!

5. The text mentions that **Newton's laws are "limits"** and that physics concepts have to be re-examined or added to as objects reach light speed. For instance, **the formulas for kinetic energy and the mass of objects traveling at near-light speed differ from those routinely used** for objects traveling, for example, at 55 miles per hour. Explain to your classmates why these new formulas are required.

    - Explain how this change illustrates the nature of science, with new ideas being tested by the international community of scientists. How long did it take for these ideas to be accepted? What various types of scientists were involved in assessing them? What tests did these new ideas have to pass to be accepted? Are they still being tested? How are these ideas now used?

6. **Explain the differences between theories, laws, models and hypotheses.** Take a current topic such as quantum entanglement or climate change that sparks debate. What pieces of the new ideas concerning "quantum entanglement" are based on existing theories, laws, and so on? What part(s) are a new hypothesis? What is required to move them from a hypothesis to a law or theory? Are these ideas a conceptual model, a mathematical model, or a physical model, or what combination of these types of models?

    - These topics do inspire debate. Find speeches on these topics and assess the credibility of the speakers, considering how they present the material.
    - Find arguments with different points of view. Assess an author's purpose in providing an explanation, process, or experiment, and discuss what issues remain unresolved. Analyze how an author's presentation organizes information and places it into categories, thus demonstrating an understanding of an author's approach.
    - What are the key symbols and terms in the discussion?
    - Evaluate the key ideas, searching for evidence or approaches that would confirm an idea.
    - Combine the ideas from various texts and other sources, and search for material that has different purposes (e.g., one article might propose an idea; another might question it; a third might provide data supporting or challenging a hypothesis).