QRMS Project 3

Due Thursday, March 20, 2008

"How many stars are visible in the sky on the clearest, darkest nights? How could astronomers estimate the total number of stars in the universe?" (cf. 3B, problem #86) Note this is talking about visible to the *naked eye*, so don't use a telescope. In a well-organized typed essay of 2-4 pages, formulate an answer to these questions. You may work alone or in a group of up to three, **but please do not consult with anyone outside of the class on this**. Groups should submit only one paper, with the names of all group members. Please staple the rubric on as a cover sheet.

In the process of answering the first of these two questions, the most important points are to decide how you will count the stars and how you will ensure that your answer is reasonably accurate. (For example, just trying to count every star in the sky would be time consuming and prone to incredible inaccuracy.) You should devote a section of the project write-up to describing what method you came up with to do this and why this method is reliable. (Convincing your reader that your answer is correct is just as important as having it be correct in the first place.) This discussion should probably touch upon both how you controlled any physical observations you made and any mathematics you used in turning this raw data into a final answer. Include all calculations you make in an appendix to your essay. Also, in the body of the essay, you should provide a summarized version of how you made these calculations with enough detail that someone else in the class who read your essay could duplicate your methods (and come up with the same answer). You should include also what your final answer is, of course. Note that coming up with a good method is not easy, so you should probably decide how you plan to do this before you make your actual observations. If you decide to use a sampling method (which is highly recommended), make sure it is an appropriate one (see Unit 5A). Some of the ideas in Units 10A and 10B may be very useful in extrapolating from your sample to the entire sky. As we won't be covering these units in class, consider this an exercise in independent scholarship.

You may be much more vague regarding the second question and need not devote as much length to it as you do to the first question: the universe is so big that we can't possibly count all of its stars by naked-eye observation or even with most (any?) telescopes. Try to come up with a method of determining a ballpark figure, to the nearest order of magnitude, say. A good strategy is to begin by identifying pieces that can be multiplied to give the final answer, as we did in our calculation of the order of magnitude of ice cream spending in Example 3 of Section 3B (p. 158).

You are free to use other organizational schemes if you think they are better, but the following outline may be a useful way to present the material. If you do use a different scheme, you should nonetheless ensure that all of these ideas are covered in your analysis. Note that the below is somewhat standard for scientific writing of this sort, so using this outline is a good idea unless you have a reason for wanting to structure your paper differently. On the other hand, such reasons do exist and you should not hesitate to present your project in the way that you think will best explain your methods and answer the overall question asked.

I. Introduction: Describe what problem you are trying to solve and give the answer you found.

II-III. Methodology/Data: Describe how you gathered data and computed your final answer. Summarize any data you collected in the process of reaching a solution. If you have a large amount of data, it may be beneficial to use a table or other graphical method to display it. Discuss why you think that the data is accurate/reliable. Discuss why the method used to reach a final answer from the data makes sense/is reliable.

IV. Interpretation: What does the data and your final answer mean? Are the numbers surprising? Larger than you expected? Smaller? Should we care? Why or why not?

V. Further Research: Discuss other, related questions that you could look into. At a minimum, you should discuss the second question in the prompt (the number of stars in the universe).

VI. Conclusion: Any final thoughts relevant to the topic? Personal reflections are acceptable here, if you want to talk about what you did or didn't learn, enjoy, etc. about this.

Helpful Hints:

(1) As always: spell-check, grammar-check, proof-read. Staple your pages together: don't just do origami with the corner; it won't work. Include the rubric as a cover sheet. Outline your argument before you begin and give your essay a title. Follow standard rules of good writing and good English.

(2) Remember, you are writing on a formal, scientific topic. The rules are a bit different than colloquial writing. First off, don't use colloquialisms. Writing on scientific topics strives to be objective and fact-oriented and for this reason is traditionally (but not always) presented in the third-person. Note that this doesn't just mean replacing "I" with "the author." Most sentences that begin "I think that" work perfectly well with these three words omitted; unless you're emphasizing that something is merely an opinion, state your facts and conclusions without this or similar circumlocutions. Typically, you should only talk about yourself if it relates directly to your procedure (e.g., "I put my thumb out in front of me, obscuring the moon from my vision."). The conclusion is an exception to this.

(3) This project involves some research, observation, and computation. You probably want to plan/do most of this before you begin writing. Likewise, make sure your plan is a good one.

(4) Finding a method is hard. You should start working on this project *early*, brainstorm with group members, try a bunch of ideas, and make sure that you know what you're doing before you begin making actual observations. If you prepare adequately, you should have no problem coming up with something.

(5) The following textbook sections contain ideas I think might be useful for this project: 2A, 2C, 3A, 3B, 5A, 10A, 10B. It may not be immediately apparent why these are useful, but if you're stuck, reading them may give you an idea of how to proceed.

(6) You may want to do your observations at a time when the moon is not full, as its light pollution would make the stars more difficult to see. New Moon is March 7th. You'll probably have a much more pleasant experience if you make your observations close to this date. Also, picking a cloudy night is a bad idea.

(7) Observations may take longer than you expect, so make sure you dress warmly.

(8) If you want to get your bearings in the sky, you may find a star chart useful. You can get one online at `http://skymaps.com/downloads.html`, `http://heavens-above.com/`, `http://www.wunderground.com/sky/index.asp`, or at many other locations. Keep in mind that you need to convince me that your method is accurate. I'm willing to believe that the stars on the map are placed correctly relatively to each other, but not that the map accurately represents the stars *actually visible to the naked eye*. Thus, while a star map may (or may not) be useful to you, merely counting the stars on the map is not an acceptable way of going about this.

(9) It probably won't be directly useful to you, but Fiske Planetarium offers free star talks for CU students on most Thursdays. See `http://fiske.colorado.edu` for more information.

(10) If you do some sort of statistical approximation (which you probably should), be sure to explain why what you're doing makes sense in this case as part of your Methodology. For example, is your sample size a good one, and are you picking your sample in a sensible way?

(11) For the second question (number of stars in the universe), you may want to look up some figures others have computed (such as the average number of stars in a galaxy, perhaps). If you do so, you should cite your source (in a method of your choice) and explain why you think the numbers the source gives are accurate/believable.

(12) Don't wait until the last minute. This isn't a project that can be dashed off in an evening (which is why I'm giving you close to a month). **Remember, Boulder is often cloudy. You will not be given an extension if the weather is bad the last few days before the project is due. Also, due to Spring Break, turning this in late is not an option. Please plan ahead.**

(13) Have fun with this. Mathematics is supposed to be fun.