Math 163 – Discrete Mathematics – Spring 2014 – Professor Janeba
Project 1 – The Grzzmorgian Protocol

Goals:

- To practice solving a complex problem that is not a routine homework exercise.
- To practice careful, detailed work in a setting where "getting it right" really matters.
- To practice communicating and explaining mathematical results clearly and professionally.
- To practice working in a team on a mathematical problem.

You have just received the following memo from a government courier:

Department of State, Sub-Undersecretary of Grzzmorgian Relations

Special Office of Diplomatic Protocol and Mathematics

April 1, 2022

Thank you for being willing to work with the SODPM. You have been recruited by virtue of your mathematical background to help us with a delicate diplomatic issue. As you know, the world was forever changed when the Grzzmorgian emissaries from the planet Woofump first contacted us from their approaching interstellar craft, then located in the outer solar system. As the media have reported, the world is torn between optimism at the prospect of learning from an (at least somewhat) more technologically advanced species, and pessimism at the possibility of interstellar invaders. We can tell you (in absolute confidence, or course) that the U.S. administration is equally split between optimists and pessimists.

Just as many other nations have done, the US has been in constant radio contact with the Grzzmorgians as their craft has slowly approached our planet. We are certainly preparing for all contingencies, and indeed one of them is that the aliens could enter orbit with guns (or death rays) blazing, despite their peaceful transmissions to date. We must also be prepared for the more desirable contingency that their stated interest in peaceful coexistence is sincere, and thus we are also planning a welcoming state dinner. This is where you come in: We have run into some significant planning difficulties; difficulties that, perhaps surprisingly, have a decidedly mathematical nature – particularly, involving logic and combinatorics. We need your help solving some of the mathematical problems the dinner's protocol poses for us.

We have learned much of the Grzzmorgians' curious customs and social mores from their radio transmissions to date. This much we know of Grzzmorgian life: Theirs is a highly formal society. Grzzmorgian protocols are complex and we want to be able to observe them strictly. Part of our problem is deciding whether this is even possible; the more hawkish folks at State and Defense think their protocol requirements are a setup – perhaps they hope we will violate one of their rules and thus give them pretext for violence. (That they would *need* a pretext may speak to the nature of their society, but that is an issue for others to study.) Consequently, finding out if it is possible to satisfy their requirements, and if so, finding out *how* to satisfy them, is of major importance. We

stress that it is equally possible that the Grzzmorgians are peaceful, and that their requirements are entirely possible to meet – in which case we want to be accommodating hosts. Note lastly there is a disturbing potential for competition between the nations of earth to obtain Grzzmorgian technology; we do not want a diplomatic faux pas to hamper our chances should such competition arise.

At the state dinner, there will be a "head table" seating five beings in a line. At the head table will be two humans and three Grzzmorgians. As far as we can determine, Grzzmorgians have three distinct genders, or at least they will during the season of their arrival. The words "male," "female," and "neuter" do not begin to capture the complexity of the Grzzmorgian species, and it appears the word "neuter" may be seriously offensive, at least as they translate the word. We will use our best translation of their gender terminology, which identifies the three genders we will deal with as Quick, Rachial, and Sessile. We will refer to them as "Q", "R", and "S" in what follows, and the human genders Male and Femle as "M" and "F." One of each of these genders (M,F,Q,R, and S) will be seated in a line at the head table. This is where the protocol gets particularly arcane. The specific requirements are listed below. Your assignment here is to determine whether it is possible to satisfy these requirements at all, and if so, to find *how many* distinct solutions exist for this problem.

1. There are five seats at the head table, arranged in a line.
2. Each being wears (exactly) one colored sash, has exactly one place card and exactly one flower at its[1] place.
3. Each being is served exactly one ceremonial drink.
4. The Female wears a purple sash.
5. There is a rose somewhere to the right of the being who has the orchid.
6. The being wearing the orange sash will be served coffee.
7. Herb tea will be served to the Male.
8. The orange sash wearer is seated immediately at the scarlet sash wearer's left.
9. The place with the star-emblem place card also has a tulip.
10. The being wearing the black sash has a planet-emblem place card.
11. Black tea is served to the being seated in the exact middle.
12. There is no one seated on the Quick's right.
13. The spaceship-emblem place card is adjacent to the place with the carnation.
14. The planet-emblem place card is adjacent to the place with the lily.
15. Hamsters must not be present at the dinner, and don't ever speak of streetlights to the Sessile!
16. Green tea is served to the being with the mountain-emblem place card.
17. Water must be one of the ceremonial drinks.
18. The Rachial must have an ocean emblem on its[2] place card.
19. The Quick is seated next to the being wearing a blue sash.

[1] We apologize, but we have given up trying to use correct pronouns and have defaulted to "it."

[2] See note #1.

Please present solutions (if there are any) as if the beings were facing the reader from across the table. If you present solutions as if the reader were behind the beings, we will understand them to mean the exact opposite order of what you intended!

We need to be able to check your work – the importance of this dinner (if it happens) – means that we must be certain you are correct. Therefore, we request and require that you explain your reasoning in sufficient detail that there is no room for doubt as to its correctness. We assume this explanation will make up the vast majority of your report. Finally, to resolve a bet The Secretary has with Defense, please compute the probability that randomly assigning the beings, sashes, place cards, flowers, and drinks will give a valid "solution" to our puzzle, explaining your computations persuasively (there is a lot of money on the line here).

In summary, you must: 1) Find all solutions, if any, to the protocol puzzle we face. 2) Persuade us through your narrative that you actually *have* found all solutions, and have not missed any. Your reasoning needs to be airtight. We presume the narrative will be extensive. 3) Answer the probability problem to resolve The Secretary's bet, explaining your answer there equally thoroughly.

Your team must now pull together all of its ideas to find any and all solutions to State's conundrum. Your team should write a professional report summarizing your work and your findings, so the State department can decide how to proceed with this delicate event. Since your report will circulate at the highest levels of government, a rough report just won't do. Plan to spend lots of time solving the problem, and even *more* time carefully writing your report.

Submission guidelines:
Preliminary report due: Friday March 14 at 4:00 p.m. at Prof. Janeba's office.
Final report due: Friday March 21 at 4:00 p.m. at the same office.
Late papers will not be accepted.

Both your preliminary and final reports will be carefully printed on plain white paper fastened with a staple. You must ***also*** submit an electronic version of your reports to Prof. Janeba via email. Use Microsoft Word or other suitable word processor. Equations, as needed, will be typed. If equations are too complicated for "plain" Word, use for example the Microsoft Equation Editor built into Word. On the front page, team member's names will be clearly visible.

Both reports will be self-contained, i.e. the reader need not have prior knowledge or understanding of the problem to understand your reports.

The preliminary report will be a formal report that shows a substantial start on the project and outlines how your group will approach the remainder. It is assumed that this preliminary report will be the foundation of your completed paper; the preliminary report counts for 10% of your project grade.

In the final report, your reasoning, calculations and conclusions will be fully explained in detail, as befits a professional report. Your audience for both reports includes both fellow students and the professionals at the Dept. of State. Some are quite familiar with your methods, others not very much so; none are experts in the particular problem you have solved. Explain accordingly. Your

explanation and presentation are as important as the mathematics, but of course your mathematical analysis must be sound, complete, and correct. It should go without saying that your grammar, punctuation, and spelling will be flawless.

Group evaluation: Your group turns in one report and everyone in the group gets the same grade. To provide some accountability, however, every group member is required to submit to their instructor an informal group evaluation no later than April 3. Handwritten, typed, and email are all OK. The evaluation should include (just!) a few sentences about how well the group worked together. The evaluation **must include** your estimate of the share of the project work that you feel each group member did, expressed as a percentage (e.g. 33%/33%/33% or 40%/30%/30%, etc.). **These percentages must add to 100%.** These evaluations will be held in confidence, and used at the end of the semester, if necessary, to adjust final grades.

A word to the wise: This project counts for about 9% of your final grade. Please make sure that your report's qualities of completeness, clarity, and correctness reflect your best abilities. Please carefully read ***all*** the instructions and resources provided.



A post-dinner press conference?