Please cite as: Magnant, C., Nasseh, S., & Flateby, T. (2016). *Mathematical writing assignment for deeper understanding and process writing.* Georgia Southern University.

Mathematical Writing Assignment for Deeper Understanding and Process Writing

The following is a detailed outline of the writing assignment originally for MATH 2332 at Georgia Southern University, Mathematical Structures but also used in subsequent courses within the mathematics major. The broad goals of this writing assignment are two-fold:

1. To delve deeper into the inner workings of a chosen proof and explore fundamental motivation of the chosen result.
2. To enhance student learning in the area of academic writing in the discipline of mathematics and achieve the Student Learning Outcome for effective writing listed in Appendix A.

According to a recent survey of major employers in the southeastern USA conducted by Georgia Southern University, writing skills are very important for hiring decisions, but absolutely critical for advancement within any career. Consequently, the overarching goals of these assignments are to prepare our students for advancement in their future careers. Additionally, a recent survey sponsored by the Association of American Colleges and Universities (AAC&U 2015), revealed that 91% of employers surveyed agreed that "a candidate's demonstrated capacity to think critically, **communicate clearly**, and solve complex problems is more important than his or her undergraduate major."

Instructor Comment: The regular Roman print is the instructions for students while the italicized text (like this) provides comments to the instructor.

For this assignment, you will research a mathematical result related to the course content along with its motivation, proof and consequences. You will write a short mathematical paper including all of these, in your own words, for a total of around three pages. Some possible ideas for topics are listed in Appendix D. You're encouraged to choose a topic not on the list, but please be sure to discuss any deviation with your instructor.

Your submissions will be scored and graded using the Scoring Rubric found in Appendix B. You will use the Scoring Rubric to guide improvements in your peers' work in the peer review process.

Instructor Comment: The scoring rubric was designed by a team of faculty in the Department of Mathematical Sciences at Georgia Southern University based on the Georgia Southern University Rubric for Assessing Student Writing as part of the University-wide initiative on

writing in the disciplines. The components of the rubric were selected to measure certain important aspects of effective writing for mathematics students.

Instructor Comment: This assignment was implemented in a sequence of courses within the mathematics major. The selection of topics and expectation of mathematical depth in the writing can be the determining factor in adapting this assignment for various levels. Through deepening the topics and expectations, this assignment can be built upon from one course to the next. For example, a second assignment (either later in the same course or in a subsequent course) could require that students select more advanced topics such as a proof of L'Hospital's rule in an Analysis course. The students may also be required to satisfy additional expectations, particularly in the areas of audience awareness and clarity of presentation.

Instructor Comment: This written assignment and topic selections should give students an opportunity to delve deeper into a concept covered in the course while, at the same time, honing important analysis, synthesis, argumentation, and writing skills. Classroom activities can and should be designed and implemented to guide students through this process of academic writing and deeper thinking (DQP - Specialized Knowledge and DQP - Mathematics-Specific Intellectual and Practical Skills).

Instructor Comment: It is critical to distribute the scoring rubric at the same time as the assignment so the students can become familiar with the expectations for quality of writing and the goals of the different traits. It is also important to discuss the rubric and how to apply it with the students, preferably also going through an example of its application as a group in class.

Instructor Comment: Due dates are approximate based on a Fall Semester beginning on August 15 and ending on December 1. Initial assignment is assumed to be assigned on September 1.

Work Log (due Nov. 1):
Maintain a work log of your time spent on this project to be turned in at the conclusion of the project. This will include dates, list of tasks accomplished, and estimates of time spent on each task. See Appendix C for an example. The objective of the work log is to get a sense of how time is spent in the writing process and make you more aware of the process of writing. (Note that although this part of the assignment is one of the last parts to be turned in, it is listed here since you should maintain the work log throughout the process.)

Instructor Comment: The Work Log is intended as a metacognition exercise that will enable the students to predict, implement and reflect upon their process of writing and deeper thinking.

Topic Selection (due Sept. 8):
Select a topic, possibly from the list in Appendix D, and research at least one academic work (e.g. a book, survey article or journal article) related to your selected topic. Topic can be

something covered in class that you wish to study in more depth or something related to the class in which you have been interested. The selection of an appropriate topic can be very challenging and so this process may require discussions with the instructor.

Instructor Comment: It is helpful to discuss topic selection in class and carefully review the students' selections for feasibility and depth of investigation. The selection of an appropriate topic is a challenging task at all levels.

Instructor Comment: Before Topic Selection, it would be best to introduce the students to AMS MathSciNet as a source of credible sources. A small activity in class could be looking up sources on MathSciNet as well as tracking a topic back to its inception by using MathSciNet references.

Proposed Work Log (due Sept. 8):
Based on the first week of work on this assignment, outline a plan for your efforts for the remainder of the assignment. This should include an idea of the amount of time you expect to spend per week on this assignment. Note that at the conclusion of this writing project, you will be asked to write a reflection on your process of writing and how the process you followed differed from your original plan.

Annotated Bibliography (due Sept. 22):
Read at least two academic works related to your selected topic and provide a brief summary (in your own words) of the results and ideas. List each citation (using plain bibtex format) with a brief paragraph summary for each.

Resources can be suggested by the instructor and are readily available through Google Scholar, MathSciNet or the campus library.

Instructor Comment: The purpose of this annotated bibliography is partly to ensure the students have found some academic sources (DQP - Information Resources) but also to practice summarizing works in a very brief form (DQP - Communicative Fluency).

Instructor Comment: For the Annotated Bibliography, it might help the class to have an activity where students read an academic paper and write a brief annotated bibliography in the style of a MathSciNet review.

Key Problem / Question Statement (due Sept. 22):
Type the main problem statement with all relevant definitions along with a brief discussion of why this problem is / was interesting or important. This should be about a page and will serve as part of the introduction.

Paper for Peer Review (due Oct. 1):

This is expected to follow an appropriate outline and contain all the necessary work for the final paper. This includes but is not limited to a motivating introduction, a fully detailed version of the selected proof, a synthesizing conclusion and any necessary examples, figures or tables as needed to enhance the written argument. You should write this draft as if it were a final version of your work.

As the peer-reviewer, you will be suggesting improvements to each other based on the Scoring Rubric (Appendix B). The reviewer will be assigned a completion grade based on the level of detail and helpfulness of your comments. You will be expected to complete your assigned reviews within three days. You are not to score the work that you are reviewing, but simply provide suggestions / coaching that may offer guidance for the peer.

Instructor Comment: When possible, reviews may be assigned to students researching similar topics. This process may also be conducted by putting students in groups and having them read each other's papers and discuss / debate comments and suggestions (DQP - Applied and Collaborative Learning). Through collaboration and discussion, the students can apply comments from other papers to their own works.

Instructor Comment: This process is intended to mimic the peer review process of academic research journals. In a small class, this can be done completely by hand by simply giving a printed copy of the written assignment to the reviewers. In a larger class, peer review can be done in some learning management systems or by email. Some portion of the grade should be based on a successful peer review, judged by the nature of and level of detail in the comments.

Instructor Comment: Here is another opportunity for an in-class activity. One such activity may include having everyone review (and score with the rubric) two short papers. Comments on the writing are discussed with the entire class as well as the scores, making this activity serve a secondary purpose of calibrating the use of the scoring rubric. It would be beneficial to also include a discussion of the comments as constructive or otherwise and strongly suggest that the students keep their comments on peers' work strictly constructive.

Peer Review (due Oct. 4):
Submit your assigned review(s) of peer's work(s).

When you receive your peer reviewed paper, the expectation is that you consider all of the reviewers comments. Please note that it is possible that the reviewer(s) may have misunderstood. In this situation, it may still be in the best interest of the writer to revise their work in an effort to clarify any misunderstanding.

Final Paper (due Oct. 10):

Produce your final paper using the suggestions from your peer reviewers as a guide. Refer to the rubric. The focus of this draft should be on more overarching aspects of the rubric like audience awareness and reasoning and quality / quantity of details.

Comments and suggestions will be provided by the instructor and / or a Student Writing Fellow (peer leader) based on the Scoring Rubric (Appendix B) within four days. Your rough draft should be at least three pages long.

Revised Final Paper (due Nov. 1):
This is expected to be a final edited / polished work. It is expected to be free of grammatical errors, inconsistencies and should strive to achieve all the top levels of the Scoring Rubric (Appendix B). Your final work should be about three pages long.

Reflection on Work Log (due Nov. 4):
Reflect on your work log, particularly noting any deviations along with possible explanations for those deviations from your work plan. Discuss the amount of time you spent on each task. Make note of what worked and what did not work in the process of writing.

When writing this reflection on your work log, try to address the following question: What have you learned about yourself as a writer and about a writing process that may or may not work for you?

Acknowledgement:
Parts of this assignment are adapted from similar strategies presented in John Bean's Engaging Ideas[1] and Patrick Bahls' Student Writing in the Quantitative Disciplines[2].

[1] J. Bean. *Engaging Ideas: The Professor's Guide to Integrating Writing, Critical Thinking, and Active Learning in the Classroom.* John Wiley & Sons, San Francisco, CA, second edition, 2011.
[2] P. Bahls. *Student Writing in the Quantitative Disciplines: A Guide for College Faculty.* John Wiley & Sons, San Francisco, CA, first edition, 2012.

Appendix A: Student Learning Outcome for Effective Writing

By completion of the degree in Mathematical Sciences, students will demonstrate logical argumentation, analysis and synthesis skills through writing by:

1. Organizing ideas and valid evidence through relevant examples, figures and tables consistent with a clearly defined purpose,
2. Introducing the work with literature citations to integrate the work into the literature,
3. Adhering to acceptable formatting and structural guidelines for mathematical writing clearly and concisely (using LaTeX when appropriate),
4. Demonstrating a nuanced understanding of audience and appropriate word choice.

Appendix B: Scoring Rubric

https://drive.google.com/a/georgiasouthern.edu/file/d/0B8f-Puo19-rsMko3b3c0YUF5UE0/view?usp=sharing

Comment: Linked to course website and attached to a printed version of the assignment.

Appendix C: Sample Work Log

8/21: Selected topic. Carefully read the assignment and scoring rubric to keep in mind the goals of the project.

8/22: Wanting to get a head start, I searched Google and MathSciNet for articles on my selected topic. Found far too many relevant results so refined search looking for surveys or books that might summarize known results. Found two appropriate sources and read the MathReview and introduction of each. Approx 2 hours.

8/24: Wrote summary of the two sources from before. Since we need at least one more, I searched through the papers cited by my two sources and found another one to be appropriate. Wrote summary of third paper. Approx 2 hours.

...

Appendix D: Potential Topic Idea List

1. Equivalence relations
2. Mathematical Induction and its applicability in different areas of mathematics
3. Functions -- history and ubiquity in mathematics
4. Functions and their role in trigonometry and calculus
5. Invertible functions (to include examples from everywhere)
6. Congruence as an equivalence relation; role of equivalence classes.
7. Boolean algebra
8. Circuit diagrams (from the AND, OR gates perspective). Some history is in order here.
9. Proof by contradiction
10. Methods of proof (development, examples)
11. The problem solving (scientific method) process as it applies in mathematics
12. Fractals