The University of Western Ontario
Department of Mechanical and Materials Engineering
GUIDELINE SUPPLEMENT FOR THESIS WRITING IN MME
(Guideline adopted from Biomedical Engineering, UWO)
(Ref: MME Grad Committee meeting – Jan 23 2009)

The reason for drafting these guidelines is to help supervisors and grad students avoid common faults and omissions that occur when preparing to draft and write a thesis. Over the course of many years, thesis examiners have observed these and other related issues, and believe that their accumulated knowledge should be shared with our junior authors. By being reminded of points that cause concern for thesis examiners, students can do their own checking on the draft versions of their thesis. We note that sometimes students take advantage of peer review by other students, which is an excellent practice. It is VERY strongly suggested that students, before submitting their thesis, ensure that someone related to their area of science, read the thesis in its entirety. Build this into your writing timeframe. The reviewer is often the thesis advisor, but may be an advisory committee member, or a fellow student. In addition, students may borrow one or two recent theses to see the general format, and layout style. This is a good idea but beware; the thesis chosen may not be considered in "excellent form" and thus not necessarily be a good guideline. We note too, that a few topic items are required for the thesis, and not optional. These guidelines are a supplement to the thesis requirements of the School of Graduate and Postdoctoral Studies (SGPS), and not a replacement.

1. **Thesis Introduction**: Whether writing an "integrated article format" thesis (formerly called manuscript style), or monograph format there should be a comprehensive introduction that provides a broad background leading to the specific content of the thesis, including a component of historical background referencing key early publications in the field. It should be a thorough literature review and not a 'fleshed out' introduction to a published paper. (The pitfall of a very short introduction is an issue mainly with the "integrated article" format.) But don't overdo the scope of the introduction. With the power of computer methods it is possible to overwhelm the introduction with numbers of references. Be mindful that the author is responsible for having an awareness of the main content of any publication referred to in the thesis. Our graduate programs have the expectation that a PhD thesis introduction would be substantially more comprehensive and thorough than a masters level introduction.

   Provide the underlying hypotheses or research questions that motivated the research and explain the links between the hypotheses or research questions and the following chapters that make up the body of the thesis. Furthermore, for some theses where technological developments have been the primary goal, it may be more appropriate to provide the orientation through a series of objectives (rather than constructing contrived hypotheses).

2. **Objectives and Hypotheses:** For an excellent summary of the relationship between hypothesis and thesis writing refer to R. Chandrasekhar "How to Write a Thesis: A Working Guide". Objectives and hypotheses are important statements that help provide a focus for a thesis (or research paper or grant application). Objectives are relatively straight-forward statements; however, hypotheses are more difficult to construct, and a few comments are provided here.

   A dictionary definition of hypothesis: "a supposition that appears to explain a group of phenomena and is advanced as a basis for further investigation; a proposition that is subject to proof or to an experimental or statistical test." There may be commonly held views or experimental results that provide a foundation for a hypothesis, but that is not necessary. There are several well known hypotheses – e.g. the sliding filament hypothesis for the sliding action of actin and myosin for the contraction of muscle fibers, or the Michaelis-Menton hypothesis regarding enzyme action in chemistry. Another example is Starling's hypothesis (referred as well by the more authoritative term as Starling's Law) relating to fluid exchanges across the capillary wall and the dependence on hydrostatic pressure. A hypothesis often implies a mechanism or process and provides a starting point for experimental or computational investigation. The hypotheses provide coherence and purpose to the entire body of work in a thesis. While it is expected that hypotheses and/or objectives will appear towards the end of the introduction and at the end of the thesis in the final general discussion chapter, it is also important to address the hypotheses or objectives that appear in individual chapters. At the end of the thesis it is also important to re-address the objectives,

hypotheses or goals described in specific chapters together with the originating hypotheses described in the introduction.

3. **Summary Discussion and Conclusions**: A conclusion and general discussion chapter is required. One cannot assume that the separate discussion sections at the end of each chapter (integrated article style) are sufficient. An integrating discussion pulls the thesis chapters together, and can also bring a specific chapter more up to date (which may well have been written 2 or 3 years earlier than the full thesis). Here again is the appropriate place to reflect on the original hypotheses and objectives and how these were addressed by the studies described throughout the body of the thesis.

4. **Diagrams:** must be legible – not just miniaturized imports off the web and absolutely must show where they come with copyright allowances if they are directly copied from another copyrighted body of work. Url's are not appropriate references for figures and diagrams. A minor modification does not excuse the author from obtaining copyright permission.

5. **Detail:** Avoid using complicated diagrams that are only marginally relevant to the thesis (e.g. complicated heart anatomy pictures – solution may be to include a side sketch or schematic with the main features in line drawing form).

6. **Figure Captions** should be comprehensive. There is a temptation to use information downloaded from web, to serve as illustrative material, rather than informative content directed to the thesis. Make the caption suit your thesis. ASIDE: Information needn't be duplicated in the text and in the caption. Keep the inferences and significance part for the main text, and the details about the graphs, charts, or tables for the caption. The author's judgment is needed here. The common practice is to make the figure captions too skimpy on information.

7. **Table or Graph.** Tables and Graphs should be appropriate for the data. Sometimes the tables are quite difficult to understand when a graph would have been better and, vice versa; sometimes the graph is the wrong way to present data that are better presented as actual values (i.e. table needed). Aside – "data" can be singular or plural, but be consistent throughout the thesis.

8. **Font Size:** Use good-sized labeling on graphs, including numbers along the axes, and take advantage of the SI prefixes for micro, nano, mega, etc. Don't get lazy and use the exponential format reported on computer printouts (e.g. 4.45 E6). Note that the font choice, and size may be plainer and slightly smaller for figure and table captions and possibly 'single spaced'. This makes them stand out as clearly separate from the regular text (a practice used in journal publications).

9. **Scales:** In our graduate programs scales for anatomical or histological slides (micrographs) are required. A scale bar is much preferred, because it preserves the "scale" even if photocopied. The scale indicator of "x1500" is only correct for exact size duplication. Scales on engineering diagrams and sketches of equipment are also required. For drawings that may have different scales in a z vs. x and y directions may need some creativity.

10. **Figure Locations:** With the advent of word processor the figures, tables, etc should be blended with the text (but give them adequate space) rather than at the end of the chapter - this makes for easier reading. Large figures may require an entire page. Don't squeeze in 2 or 3 lines of main text just to fully fill the page. Sometimes a panel of micrographs or charts could appear on a single page for comparison purposes. Be cautious not to so miniaturize the individual elements of the panel that the important details are lost, or unreadable.

11. **Figure Quality** should meet a high standard. **Excel** is not a proper graph package and does not normally produce publication quality graphs – students should use a "real" graphing package.

12. **Copyright:** The SGPS thesis guidelines have a section focused mainly on reproducing text, and giving proper credit. However, diagrams and graphs from published material, and often material published on the web, are protected by copyright. UWO Library consultants are willing to advise on copyright. Original sources must be acknowledged, and in most instances the copyright is held by the journal (not the author), and permission to copy must be asked for. Please note that some

journals do not require permissions for figures etc. used in a student's own thesis or dissertation, e.g. Cancer Research, or Cancer Imaging, provided proper referencing to the published paper is provided. Include this detail in the appropriate appendix. Each journal has a standard phraseology on how the permission is to be identified. Don't take copyright permissions lightly. Planning ahead can get this important and time-consuming task looked after without undue trouble. Having to remove diagrams from your PhD thesis because of copyright violation is irksome to the student (and very annoying to examiners). Obtaining copyright permission to reproduce in whole or in part a sketch, graph or drawing IS A REQUIREMENT. A minor modification doesn't satisfy this requirement (such as adjusting the labeling, or leaving out part of the anatomical drawing in a text). If one were to redraw a figure from scratch, using a published figure as a guide, then an acceptable recognition would be to acknowledge the original without obtaining permission. It is recommended (as noted on the SGPS website) that the authorizations to 'copy' figures, etc. be included as a thesis appendix.

13. **Collaborative Research and First Authorship:** There is a continuing trend for researchers to undertake projects in biological and medical research that are cross-disciplinary – small animal imaging and stem cell research, multimodality imaging approaches, computational biology and phantom design, physical chemistry and tissue engineering. This is an excellent trend and many students are participating in such projects. However, the intellectual property ownership becomes blurred – a critical issue for students competing for first-authorship recognition. Normally a PhD thesis would contain chapters only related to work that is published or planned for publication for which the student is also the first author. (The issue concerns particularly the 'integrated article' format of the thesis.) If data and their analysis have already been used as part of a thesis that work CANNOT be used again in another thesis (recent communication from Assoc. Dean, SGPS). When research projects are shared among summer research students, masters-level grad. students or postdoctoral researchers then joint first authorship may be appropriate (policy of some journals). However, joint first author may not be satisfactory for two PhD candidates working on overlapping projects.

    Related Guideline from **SGPS: 1.1 Doctoral Programs**: Every candidate for the Doctoral degree must complete a thesis. The thesis must indicate in what respects the investigation has increased knowledge of the subject. A candidate may not submit a thesis that has been previously accepted for a degree, but may, with the permission f the Graduate Program, incorporate material included in a previous thesis. Hence, there is some latitude; it is strongly recommended that students and their supervisors plan ahead to either subdivide projects into separate publications (with differing first authors) or seek permission from their respective graduate programs. (Debating this issue at the close of the PhD oral defense is not a suitable time.)

14. **References:** Whether for the integrated manuscript style, or monograph, references should conform to a standard used by journals. If a student's work is in orthopedic biomechanics, for example, then the Journal of Bone and Joint Surgery might be a very good choice. A reviewer must accept a standard journal format, even if it isn't his or her favorite. Of the 100s of style possibilities in Reference Manager or other package choose one that fits one of your publications. In that way you are off the hook when an examiner questions your choice. ASIDE: It is strongly recommended that when referencing a text, make specific reference to the page or pages that are pertinent, or the 2 or 3 chapters. This is often required by journals, but sometimes overlooked by students, and a real nuisance if an examiner requires that change before final submission. References are also a frequent source of typographical and style errors. Understandably the references might be the last major item to be checked before the panic deadline a few days hence. The impression given to examiners is that the references are not verified with frequent resulting errors in the author listing and citations.

15. **Theoretical and computational studies** require a careful presentation of the assumptions made. Assumptions, such as isotropy and linear elastic behavior for mechanics of tissues, may be simplifying, and perhaps essential to allow the modeling to proceed without excessive complication. Referencing published work where similar assumptions are made is most helpful. For theoretical work the discussion section must include a comprehensive discussion of the major assumptions, and their consequences. Validation is critical in theoretical work (somewhat like establishing controls, and method verifications in experimental bench science). It is insufficient to compare model predictions

with known experimental findings and remark that the similarities 'validate' the model. Such comparisons are nice, but lack scientific rigor.

16. **A table of abbreviations and symbols** used in the thesis is a necessary addition. Definitions of words that may seem like jargon, but are becoming common in your field might be included in such a table.

17. **Spelling:** Decide before writing the first chapter. If a integrated article style, students are advised to use the spelling of one of their key articles, and convert other chapters to fit. This seems like a silly request, but gets annoying for examiners after several switches back and forth. Spellcheck is always worth running, even though it accepts many words, like LEAD when you mean LED. Aside: "however" is not a conjunction (like "and"), but an adverb, and usually requires a ";". Also the diphthong such as ae in "orthopaedic" is no longer required for English spelling (according to the Oxford Dictionary). You must use a consistent approach for abbreviations and symbols throughout the thesis, even if different publications (as chapters in the thesis) have different terms for your mathematical formulations.

18. **Units** are relatively standardized with the SI system. However, original articles may have British units, or old mixes of "psi" etc. from engineering. It might be useful to give the stress unit in MPa (but include the original Kg/cm2, or psi in brackets). You may be surprised how many times the unit conversions have been done incorrectly in journal publications, i.e. have slipped by the referees.

19. **Statistics** are becoming more sophisticated with special software packages. Some journals actually require a statistician's sign-off to attest to the suitability of the tests used. Statistical analysis in biomedical research is reportedly the most abused area of medical science. Explain what you did in plain English, and ensure that your results make sense. Refer to statistical texts to get explanations of Stats Package outputs. Ignorance is no excuse. Sometimes an examiner from outside your specialty will ask to have the statistical output described in plain English, perhaps to ensure you know what you did, or perhaps to bring himself 'up to speed'. Report means and SDs in the standard of your journal, and don't include superfluous or insignificant digits. (High school students in the good old days would lose marks for this mistake.) Tables of numbers with oodles of insignificant figures are bulky and unhelpful.

20. **Jargon** is language used that is understandable only to the insider – e.g. your fellow students, or orthopedic surgeons with shortcut language for medical imaging. In general avoid the use of jargon. If words are becoming a standard for the field, but may be confused, then a glossary of terms can include them. If such language has become standard in the published literature, then it is acceptable to the thesis.

21. **Precision and Accuracy:** Students often get confused about the difference between precision and accuracy – and the related issue of significant figures for text and tables (a popular question for a thesis defense).

22. **Writing Quality:** Often the writing quality of the "manuscript" thesis varies considerably indicating that the care taken for the publication chapters has not carried through to other chapters, such as the general introduction, and general discussion chapters. Understandably the chapter describing work that is for a "manuscript in preparation", to be submitted in the fullness of time will not have had the scrutiny and editing of an accepted manuscript. It is suggested that thesis authors attempt to incorporate the same concise and sharp scientific writing style that was developed for the published chapters (not a simple task).

23. **Verbosity** - this is a big issue as students seem to have misplaced the skill of 'wordsmithing'. Since the author is often not the best judge of circumlocution we suggest a fellow student, or advisory committee member who could provide fresh eyes on a writing style. Peer review is very much a part of a career in science. Get used to it.

24. **Verb Tenses:** Be mindful of the appropriate use of the past and present tenses. There are a number of standard texts that would help sort this out (not a simple issue). In addition the active and

passive form should be used appropriately. There is a convention that the past tense is used for research papers, and that the present tense could be used for a literature review of published papers. Conclusion statements from your papers can be written in the present tense. Supervisors and journals vary in their style preferences. There are two superb books by Robert Day - Scientific English and How to Write Publish a Scientific Paper.

25. **Include a CV** as noted in SGPS guidelines: It helps to identify the student with regard to academic discipline or training, language skills, university experience, including summer research, and a listing of presentations or publications, some of which may be outside the thesis research. It is appropriate to include manuscripts 'in progress' i.e. submitted to journal 'x', accepted or in press. Manuscripts planned for submission may be included, provided they are definite, rather than a long term dream. Committed involvement in competitive sports, performing arts, or community activities can be noted but not required. Details about summer jobs in high school need not be included. The format of the CV is undefined, but usually starts with the listing and university identification for completed degrees. The listing of publications can be in a format different from the main thesis.