1 Introduction

This document describes the rules, regulations and procedures that guide the graduate students in Bioinformatics Specialization in the Department of Computer Science and Engineering (CSE) at the University of Nebraska-Lincoln (UNL).

The Bioinformatics Specialization in CSE shall offer programs of study leading to the degrees:

- Master of Science in Computer Science (Bioinformatics Specialization)
- Doctor of Philosophy in Computer Science (Bioinformatics Specialization)

1.1 Bioinformatics Graduate Advisory Committee

The chair of the CSE department shall appoint a Bioinformatics Graduate Advisory Committee. The mission of the Graduate Advisory Committee shall be to develop and maintain excellence in the bioinformatics graduate specialization. The Bioinformatics graduate advisory committee acts as a sub-committee of the CSE graduate committee.

The bioinformatics graduate advisory committee of the CSE department shall govern all aspects of the bioinformatics graduate specialization. The committee is composed of three faculty members, a majority of which are from CSE. Questions pertaining to any aspect of the graduate specialization may be directed to the chair of the advisory committee.

The Bioinformatics Graduate Advisory Committee in general oversees the bioinformatics graduate specialization in the CSE department. Specific duties include recommendations for graduate admission to the departmental Graduate Committee, overall supervision of the Bioinformatics Specializations within the MS and Ph.D. programs, monitoring of graduate students’ progress toward degree and evaluation of graduate students for University-sponsored financial aid. Questions and clarifications relating to these aspects of the graduate program can be directed to the chair of the bioinformatics advisory committee.

Since the bioinformatics graduate specialization is part of the CSE graduate program, the CSE Department’s graduate committee has final authority on all aspects of the bioinformatics graduate specialization, including admission of students into the program, dismissal of students from the program, PhD qualifying exams, appeals to graduate committee decisions, and changes to degree requirements. Thus the bioinformatics graduate advisory committee manages all aspects of the bioinformatics specialization, subject to approval by the CSE graduate committee.
MS Program (Bioinformatics Specialization)

2 Introduction

The objective of Master of Science in Computer Sciences with a Bioinformatics specialization is two-fold: 1) to prepare graduate students for advanced professional practice as bioinformaticians, and 2) to prepare graduate students for doctoral studies in bioinformatics. The program will prepare graduate students through classroom, laboratory instruction and research/project experiences based in math, computer science and engineering and biosciences. Students will be required to do a masters thesis or a masters project. Students who want to pursue doctoral studies will be strongly encouraged to do a masters thesis. Internships with local companies will be encouraged and may be taken for credit of up to 3 course hours. The proposed specialization integrates instructional topics, problem solving, communication and teamwork.

The program focus is on advanced knowledge and skills in Design and Analysis of Algorithms, Graph Theory applications to Bioinformatics, Machine Learning, Databases and Information Retrieval systems. The program also builds a foundation in Biosciences including Microbiology, Genetics and Molecular Genetics, Molecular Phylogenetics, and Genetic Engineering. Particularly in the lab, students are expected to develop problem solving abilities, written and oral communication proficiency, and team and organizational skills. Flexibility within the program allows students to pursue a variety of related topics, such as Database and Information Systems, Computer Networking, Structural and Algorithmic Graph Theory, Information Integrity and Security, Genetic Engineering and Molecular Biology. With these attributes, graduates are prepared for pursuing doctoral studies or to take leadership positions in the bioinformatics industry.

2.1 Degree Options

Two options are available for the Master's degree in Computer Science with a Bioinformatics Specialization. Every student should discuss his/her program with an advisor before deciding on an option. The thesis option (Option I) is intended for students who intend to pursue a career in research or for those planning further graduate study. The project option (Option III) is generally recommended for students who plan on the MS being a terminal degree.

Students choosing thesis option must decide on an advisor as soon as possible. This helps in planning the background necessary for working on a thesis research project. It is expected that the student and the advisor will jointly plan all the steps in the graduate program.

2.2 Admission Requirements

Applicants must have a Bachelor of Science degree in Bioinformatics, or a Bachelor of Science degree in Computer Science and a minor in Biology, or a Bachelor of Science degree in Biology (or Master of Science in a related field, e.g. Agronomy) and a minor in Computer Science.
However, students with background in only one of the two areas will also be considered for provisional admission if they have a good academic record. Background should be similar to the proposed UNL program for a Bachelor of Science in Bioinformatics. In particular, the applicant shall have taken courses equivalent to the prerequisite courses listed in Table 1. An applicant who has not had all of the required background courses may be provisionally accepted and required to take the remaining courses as deficiencies. Deficiency courses (and any prerequisites thereto) may not be taken for graduate credit toward this degree. A minimum grade of B or better is required for every deficiency course.

<table>
<thead>
<tr>
<th>COURSE NO.</th>
<th>COURSE TITLE</th>
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</thead>
<tbody>
<tr>
<td>1. CSCE 156</td>
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<tr>
<td>2. CSCE 230</td>
<td>Computer Organization</td>
<td>3</td>
</tr>
<tr>
<td>3. CSCE 235</td>
<td>Intro to Discrete Structures</td>
<td>3</td>
</tr>
<tr>
<td>4. CSCE 310</td>
<td>Data Structures &amp; Algorithms</td>
<td>3</td>
</tr>
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<td>5. CSCE 4xx</td>
<td>Any course in CSE Systems Track</td>
<td>3</td>
</tr>
<tr>
<td>6. MATH 106</td>
<td>Analytic Geometry and Calculus I</td>
<td></td>
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<tr>
<td>7. MATH 107</td>
<td>Analytic Geometry and Calculus II</td>
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<td>8. MATH 314</td>
<td>Applied Linear Algebra</td>
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<td>9. STAT 380</td>
<td>Statistics and Applications</td>
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<tr>
<td>10. BIOS 201, or BIOS 301, or BIOS 312</td>
<td>Cell Structure and Function, General Genetics, Fundamentals of Microbiology</td>
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<tr>
<td></td>
<td>Introduction to Biochemistry</td>
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<tr>
<td>11. BIOC 221, or BIOC 321</td>
<td>Elements of Biochemistry</td>
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</table>

Table 1: Required Prerequisite Courses

2.3 Program of Study

Graduate College policy specifies three options for a Master's degree program. Options I and III are available in this specialization. Courses taken under either option must satisfy the required, breadth and depth course requirements listed below. In addition, each option has its own criteria for the total number and distribution of credit hours.

2.3.1 Course Requirements

The courses listed in Table 2 constitute required core courses. The requirement for a specific required course is considered satisfied if its 400-level counterpart was taken prior to admission into this degree program. In that case, the 800-level course may not be taken for degree credit. However, if the 400-level counterpart was not taken prior to admission, then the 800-level course must be taken, and counts toward the credit-hour requirements described in Subsections on Option I and Option III.
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<th>Course Hrs.</th>
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<td>CSCE 8xx</td>
<td>Computational Molecular Biology</td>
<td>3</td>
</tr>
<tr>
<td>BIOS 820, or BIOC 831</td>
<td>Molecular Genetics, Biochemistry</td>
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</tbody>
</table>

Table 2: Required Core Courses

2.3.2 Breadth Requirements

A student must take at least two courses in each track. There are three tracks of courses: Theory, Biosciences and Applications. The course tracks are listed in Table 3. Breadth requirements are the same for both options. The breadth requirement can be satisfied if the 400 level counterpart of any course was taken prior to admission. When CSCE 896 and 990 are taken as regular courses, the graduate committee may assign them to a track so they can fulfill breadth requirements. Any such course not so assigned cannot apply towards breadth requirements. In addition, CSCE 897, CSCE 898, CSCE 899, and CSCE 996 do not apply towards the breadth requirements.

2.3.3 Depth Requirements

2.3.3 Depth Requirements

To satisfy the depth requirement, the student must take Thesis or Project credit hours plus at least 9 (15 for non-thesis option) credit hours of 900-level courses (or 800-level courses with no 400-level component). Within any single track, a maximum of 18 credit hours may be counted toward the degree. The total number of independent study-type courses (e.g. CSCE 896, CSCE 897, CSCE 898, CSCE 899, CSCE 990, CSCE 996) should not exceed 9 credit hours. When CSCE 896 and 990 are taken as regular courses, they do not count toward the 9-hour limit.

2.3. Option I -- Thesis Option

The student choosing this option must write and defend a research oriented Thesis in accordance with department and Graduate College policies. The program may include an internship for 1-3 hour course credit. This option requires at least 30 credit hours of graduate level courses satisfying the following:

1. At least 6 hours of Master's Thesis (CSCE 899).
2. At least 24 hours of graduate course work other than thesis.
3. At least 15 hours of CSCE courses (Including required, breadth and depth courses but excluding project and thesis.)

4. At least 9 hours of (graduate only, asterisk 800 and 900 level courses)

2.3.5 Option III -- Non-Thesis Option:

The student choosing this option must complete a Project under the direction of his/her advisor, submit a written project report to his/her supervisory committee, and pass an oral examination conducted by the supervisory committee covering the project and other course-work. The program may include an internship of 1-3 hours course credit. This option requires at least 36 credit hours of graduate level courses satisfying the following:

1. Not less than 3 nor more than 6 hours of project (CSCE 897),

2. Enough hours of other graduate work to reach a total of at least 36 hours, including the project,

3. At least 15 hours of CSCE courses (Including required, breadth, and depth courses but excluding project credit, CSCE897, 3-6 hrs.)

4. At least 15 hours of courses that are open only to graduate students (excluding project but including breadth and depth courses). The 18 hour requirement of graduate only level courses is fulfilled with the inclusion of the project credit hours. (CSCE897)

2.3.6 Memorandum of Courses

Same as the regular MS program.

2.3.7 Supervisory Committee

The examination committee for the MS degree in Computer Science with the bioinformatics specialization follows the same guidelines as for the regular CSE MS program. The MS examination committee must include two CSE faculty members, and must include at least one life-sciences faculty.

Choosing an Advisor: The choice of an advisor is based on a student’s goal for an M.S., upon approval of the Chair of the departmental Graduate Committee.

2.3.8 Thesis/Project Report

Same as the regular MS program.

2.3.9 Final Oral Examination

Same as the regular MS program.
2.3.10 Final Report
Same as the regular MS program.

Ph.D. Program (Bioinformatics Specialization)

The objective of the Ph.D. program in Computer Science with a Bioinformatics Specialization is to provide qualified candidates with the opportunity to pursue a course of study that will bring them to the frontiers of knowledge in an area of bioinformatics and engage them in high quality research under the direction of a Supervisory Committee. This research should culminate in a dissertation presenting significant results, which are publishable in recognized refereed journals.

3.1 Admission Requirements

To enter the Ph.D. program a student must have completed the equivalent of UNL’s Master's degree in Computer Science with a specialization in Bioinformatics. The student must have the equivalent of 36 semester hours (30 with thesis option) of graduate course work including at least 18 hours of advanced courses in Computer Science & Engineering and Biosciences. Students entering the Ph.D. program must have adequate background to successfully take the Bioinformatics Specialization Qualifying Examination for the doctorate within twelve months of matriculation.

3.2 Examinations

Students are generally admitted to the Ph.D. program on a provisional basis. Every Ph.D. student must take the Bioinformatics Qualifying Examination no later than one year after completing requirements for an M.S. degree. Once the student has passed the Qualifying Examination, he/she is no longer considered provisional. Each student must also pass a written Comprehensive Examination after the student has substantially finished the course work for the Ph.D. After the student has decided on a dissertation topic and obtained preliminary results, an oral Candidacy Examination must be scheduled for approval of the research topic by the student's Supervisory Committee. After the dissertation research work is complete and written up, a public defense of this work must take place during the Final Oral Examination.

3.3 Choosing an Advisor

The choice of an advisor is based on a student’s goal for a Ph.D. It is important to realize that the research program is a cooperative effort between the student and the advisor. The advisor has the overall responsibility for the direction and course of the student's research program. The advisor must be a Fellow of the Graduate Faculty in CSE. The Bioinformatics Graduate Advisory Committee, in consultation with the graduate student, will recommend the appointment of the advisor for the Supervisory Committee to the Chair of the departmental Graduate Committee.
3.4 Supervisory Committee

The purpose of the Supervisory Committee is to assist the students in preparing a program to enable success in the Ph.D. program and in evaluating the research. The Supervisory committee for the PhD degree in Computer Science with the bioinformatics specialization follows the same guidelines as for the regular CSE PhD program. The Supervisory Committee can be formed only after the student has passed the Qualifying Examination. The Supervisory Committee for a student should consist of at least four Graduate Faculty Fellows including one from a life-sciences department. The advisor acts as the chair of the committee. The advisor generally helps the student in forming the supervisory committee. The student and the advisor must then submit the “Recommendation for Appointment of a Supervisory Committee for the Doctoral Degree” form (Appendix N) to the Bioinformatics Graduate Advisory Committee chair for his/her signature. After the approval by the Graduate Advisory Committee Chair, the form is forwarded to the Departmental Graduate Committee Chair for approval and then to the Dean of Graduate Studies for final approval of the Supervisory Committee.

A Reading Committee consisting of two members of the Supervisory Committee will be appointed by the Supervisory Committee. The chair of the committee must not be a member of the Reading Committee. The dissertation must be approved by the Reading Committee before the final oral examination can be scheduled.

3.5 Program of Study

A total of 90 credit hours are required of which 24 to 30 may be for dissertation. The remainder must reflect course work that shows certain breadth as well as depth in the following three tracks: CSE Theory, Biosciences, and CSE Applications. For breadth, 3 courses in each track must be taken. The depth courses are determined by the student in consultation with his/her research advisor. At least 30 semester hours of course work must be in advanced courses open only to graduate students. Among 30 hours, at least 20 must be in Computer Science and 10 in Bioscience.

No fewer than 45 credit hours must be completed at the University of Nebraska-Lincoln. A minimum residency at UNL is also required (Consult the Graduate Bulletin for details).

The program of study must be filed with the Graduate Studies office before the student has completed 45 credit hours. The supervisory committee should meet to review and approve the program of study and general area of research for the dissertation. A “Report of the Supervisory Committee on Program of Studies for the Doctoral Degree” is then forwarded to the Graduate Studies office. Any subsequent change in the program or in the dissertation topic must be approved by the supervisory committee and the action reported to the Graduate Studies. The program of study cannot be filed until the student has cleared all the deficiency courses listed in his/her Certificate of Admission.
3.6 Qualifying Examination

A graduate student working towards a Ph.D. must pass the Ph.D. Qualifying Examination in each of the three tracks with a high pass in at least one track, as explained below. The student must pass the Qualifying Examination in no more than two attempts. The Bioinformatics tracks are described in Table 3. The bioinformatics graduate advisory committee, in consultation with CSE graduate committee, organizes the qualifying examination. The two CSE tracks examinations will be same as the regular CSE qualifying examination and must be taken at the time regular CSE qualifying examination is given. The exam for the bioscience track tests breadth of knowledge for required courses as described in Table 2.

A Ph.D. student shall make his/her first attempt at the Qualifying Examination no later than the first year after completing the M.S. in computer science. Students coming to our graduate program from other schools must also pass the Qualifying Exam within the first year of graduate study with MS degree.

The Qualifying Examination will be offered both in the Fall and Spring Semesters (on an as needed basis). To pass the Exam the student must obtain two passes and a high pass. The students must clear the examination during their first year. Under no circumstance would a student be allowed to continue in the Ph.D. program past their third semester without clearing the examination.

3.7 Comprehensive Examination

The Ph.D. Comprehensive examination shall be conducted by the Ph.D. Supervisory Committee of the individual student. The Comprehensive examination will be given only after the student has completed at least 54 hours of course work. The comprehensive examination will be a written examination and will be designed to test breadth of knowledge. The Supervisory Committee will grade the written examination and declare its results. If a student fails the Comprehensive Examination, the Supervisory Committee may decide to give a second chance to the student or recommend termination of graduate program. The comprehensive results should be reported to the graduate college at least seven months before the final oral examination.

3.8 Candidacy

Upon the successful completion of the Comprehensive Examination, the Supervisory Committee will normally recommend the student for admission to candidacy. The Committee, however, may require additional examination(s). The student must file the “Application for Admission to Candidacy” form with the Office of Graduate Studies. The term for candidacy is three years and the student is expected to complete the dissertation during this period. Following admission to Candidacy the student must register for graduate classes during each academic year semester until he/she receives the Ph.D. degree.

3.9 Dissertation Proposal
After the student is admitted to candidacy, it is expected that the student devotes most of the time working on a specific research problem that will lead to a dissertation. The topic sometimes is determined by the advisor, while at other times, it is derived by joint effort. After the student has decided on a dissertation topic and obtained preliminary results, an oral examination must be scheduled for approval of the research topic by the student's Supervisory Committee.

### 3.10 Dissertation

All Ph.D. students must complete a dissertation under the supervision of a Supervisory Committee with duly recognized and approved Chair. It is expected that the work done will makes an original contribution to the field. It is expected that the work is of a quality that can be published in refereed journals, if it has not already been published. The student is required to write the dissertation in a standard style (Use the “Guidebook for Preparing your Thesis or Dissertation” available from the Office of Graduate Studies.)

Following a thorough review by the Chair, copies of the dissertation are given to the members of the Reading Committee (a subset of the Supervisory Committee). The student must give the committee at least two weeks for review. Upon approval of the Reading Committee a copy of the completed “Application for Final Oral Examination” form and a copy of the dissertation is submitted to the Office of Graduate Studies, at least three weeks prior to the final oral examination.

### 3.11 Final Oral Examination

The final oral examination is required for all Ph.D. students. The oral examination will be scheduled for two hours and consist of the presentation and defense of the research. The presentation is open to the public and the student is required to give an abstract (electronic copy) to the office to be used for advertising. After the public presentation and a question-and-answer period, the remainder of the examination is conducted privately by the supervisory committee. The examination is based on the project and other course work.

The supervisory committee may require the student to make changes to the dissertation and/or conduct additional research and the advisor is generally responsible for making sure that the work is completed. The advisor decides on the grade of the Ph.D. dissertation.

### 3.12 Final Report

After appropriate changes have been made to the dissertation based on the comments of the committee, and the supervisory committee has approved the dissertation, the student must make several copies of the dissertation. The student is required to give a hardbound copy to the advisor as well as the departmental office. It is also customary to offer each member of the supervisory committee a copy of the final report. The student must also submit two unbound copies for the Library. All final copies and signed forms are presented to the doctoral specialist (in the Graduate Studies Office) for final approval before being deposited at the University Libraries.
TABLE 3

Graduate Course Tracks for Bioinformatics
The Algorithms/Theory track below mirrors Theory track in CSE and Systems/Applications track is a union of the Systems and Applications tracks in CSE. For courses not listed below students should seek advice from the advisor or the supervisory committee.

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<tr>
<th>ALGORITHM/THEORY</th>
<th>BIOSCIENCES</th>
<th>SYSTEMS/APPLICATIONS</th>
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<td>CSCE 821</td>
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*Comp. Molecular Biology

**MS Option I**:
- 24 hours courses + 6 hours thesis
- CSCE Courses: At least 12 cr. Hrs.
- Breadth: At least 6 hours in each track
- Depth: Thesis + 9 cr. hrs of graduate only courses (*800 or 900-level courses)

**MS Option IIIA**:
- 3 hours project + 33 hours of coursework
- CSCE Courses: At least 15 cr. Hrs.
- Breadth: At least 6 hours in each track
- Depth: Project + 15 cr. hrs of graduate only courses (*800 or 900-level courses)

**MS Option IIIB**:
- 6 hours project + 30 hours of coursework
- CSCE Courses: At least 15 cr. Hrs.
Breadth: At least 6 hours in each track
Depth: Project + 15 cr. hrs of graduate only courses (*800 or 900-level courses)

**PhD:**

Breadth: At least 3 courses in each track.
Depth: Determined by supervisory committee

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**ALGORITHM/THEORY**

CSCE 821 Found of Constraint Satis Theory
CSCE 823 Des & Analysis of Algorithms
CSCE 827 Combinatorial Methods for Comp Sci
CSCE 828 Automata, Comp & Formal Lang
CSCE 829 Parallel Algorithms & Prog
CSCE 841 Approximation of Functions
CSCE 847 Numerical Analysis II
CSCE 865 Intro to Mathematical Logic I
CSCE 8XX Comp. Molecular Biology
CSCE 920 Formal Languages
CSCE 923 Dev and Analysis of Eff Algorithms
CSCE 924 Graph Algorithms
CSCE 925 Scheduling Theory
CSCE 935 Mathematical Theory of Finite Automata
CSCE 870 Computer Graphics
CSCE 942 Numerical Analysis III
CSCE 975 Computational Algebra
CSCE 977 Data Encryption

**SYSTEMS/APPLICATIONS**

CSCE 810 Information Retrieval Systems
CSCE 813 Database Systems
CSCE 825 Compiler Construction
CSCE 832 Vector and Array Processor Arch
CSCE 833 Distributed & Multiprocessor Arch
CSCE 834 VSLI Design
CSCE 855 Operating Systems Practice
CSCE 861 Software Engineering
CSCE 862 Communication Networks
CSCE 863 Introduction to Coding Theory
CSCE 866 Software Design Methodologies

**BIOSCIENCES**

BIOS 816 Comp-aided Sequence Analysis Primer
BIOS 818 Advanced Genetics
BIOS 820 Molecular Genetics
BIOS 830 Molecular Phylogenetics
BIOS 831 (BIOS 831) Biochemistry I
BIOS 832 (BIOS 832) Biochemistry II
BIOS 932 Proteins
ASCI 905 Animal Industry Seminar
AGRO 919 Plant Genetics
ASCI 932 Quantitative Animal Genetics
BIOC 933 (BIOS 933) Enzymes
BIOC 934 (BIOS 934) Nucleic Acids
BIOC 942 (BIOS 942) Genetics, Genomes, &CSCE 966 Software Architecture and Frameworks
Bioinformatics of Prokaryotes
BIOS 952 Phylogenetic Co-evolution
BIOS 958 Genetic Ecology
BIOS 964 Signal Transduction

BIOS 919 Plant Genetics
CSCE 952 Advanced Computer Networks
CSCE 956 Advanced Software Engineering
CSCE 963 Software Process Engineering
CSCE 970 Pattern Recognition
CSCE 974 Genetic Algorithms
CSCE 976 Artificial Intelligence
CSCE 978 Human Factors in Computer Systems
CSCE 979 Neural Networks & Genetic Algorithms