

# Ph.D. in Informatics '07 Handbook<sup>1</sup>

The Indiana University School of Informatics, the first of its kind in the country, was created as a place where innovative multidisciplinary programs could thrive, a program where students can apply the skills of technology to a range of other fields. The School announced a new Doctor of Philosophy (Ph.D.) degree program in Informatics beginning in the fall of 2005 and offered on the Bloomington (IUB) and Indianapolis (IUPUI) campuses. (The IUPUI program is administered with the approval of Indiana University, Bloomington.) This handbook is a “work in progress.”

## Areas of Research

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Faculty research projects often involve representatives from several different research areas, working together to develop innovative and even revolutionary new solutions. While students can expect to concentrate in particular areas, they will also be expected to explore the broader significance of their work as well as ways that their expertise can be leveraged to solve problems outside of their own domains. The following lists the main research areas in the School of Informatics; the existing and potential combinations of these domains are too numerous to list.

- **Bioinformatics** (IUB and IUPUI)  
Sequence pattern recognition, comparative genomics, structural genomics, fragment assembly in DNA sequencing, systems biology, models of evolution, molecular modeling and drug design.
- **Chemical Informatics** (IUB and IUPUI)  
Molecular modeling, computational chemistry, computer-aided drug design, 2D and 3D chemical structure coding and searching systems, analysis of data from high throughput screening and combinatorial chemistry.
- **Complex Systems, Networks, Modeling and Simulation** (IUB)  
Artificial Life, complex networks, modeling and simulations of complex systems, self-organization, Multi-agent systems, computational biology, nonlinear dynamics for chemical and biological systems, adaptive systems; evolutionary computation; machine learning; neural networks, Internet/Web modeling and mining, computational intelligence.
- **Security Informatics** (IUB)  
Economics of security, user-centered design of security, cryptographic primitive design, security modeling, foundational cryptography, threat assessment and analysis, protocol design, provable security, security heuristics, light-weight cryptography, network security,

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<sup>1</sup> On July 1, 2005, the Department of Computer Science transferred administrative authority from the College of Arts and Sciences to the School of Informatics. The Ph.D. in Computer Science will follow the rules specified by that department. The Ph.D. in Informatics will follow the rules described in this document.

privacy, security auditing, security and computer forensics.

- **Discovery and Application of Information (IUB)**  
Discovery from the Web, text, databases, and data streams; algorithms, technologies, and applications for mining, filtering, and classifying those sources; and modeling, managing, and integrating information and knowledge.
- **Health Informatics (IUPUI)**  
Electronic health records, health data exchange, standards and terminology for health data, clinical decision support, consumer health informatics, technology to enhance patient safety, telehealth application development and implementation, ontologies, mining clinical data, natural language processing.
- **Human-Computer Interaction Design (IUB and IUPUI)**  
Interaction design, computer supported cooperative work, new media, dynamic visualizations, computer-mediated communication, usability and evaluation methods, collaborative shared surfaces, external representations, augmented reality, learning systems.
- **Logical and Mathematical Foundations of Informatics (IUB)**  
Computational complexity theory, mathematical foundations of computation, analysis of algorithms, models of computation, substructural logics such as linear and relevance logic, category theory, proof theory, information based logics, algebraic logic, and relations between computation and logic.
- **Music Informatics (IUB)**  
Digital music libraries, music recognition (audio, optical, time-sequence), modeling musical expression, musical accompaniment systems, computational music analysis, music information retrieval.
- **Social and Organizational Informatics (IUB)**  
Gender and technology; gender and informatics; cultural variation and informatics; free/libre and open source software; social dimensions of information and communications technology; methodologies for developing an informatics knowledge base; the ethics of information and informatics; privacy; file sharing, blogging and other mechanisms of collaborative ad-hoc filtering.

## **Program of Study**

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Students in the doctoral program will explore the connections among technology, theory, social analysis, and application domains in a diverse and multidisciplinary curriculum. This curriculum will include core courses and seminars in informatics; an informatics subdiscipline (the current subdisciplines are bioinformatics, chemical informatics, health informatics, human-computer interaction, and social informatics, and more are in development); courses in methodology and theory; electives in related disciplines inside and outside of the School leading to a Ph.D. Minor; and a dissertation. In addition, students will be encouraged to pursue internships as part of the elective courses or independent studies of their program.

The School is also exploring other possible tracks for future implementation, which may include new media, security informatics, music informatics, and complex systems, networks, and modeling and simulation.

## **Employment Opportunities**

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Graduates of this program are expected to enter academic positions in research and teaching universities or to conduct research for industries that use informatics. They should be able to shape the direction of information technology in the scholarly work they do on the social, organizational, and design environment of technologies as well as in designing solutions for the issues confronting the biological, chemical and health-based scientific communities.

## **Values**

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Ours is the first Ph.D. program (in the U.S.) to carry the label “Informatics.” Moreover, in 2004 and 2005, we expanded our faculty significantly, bringing in new faculty from around the world, who transit across a diverse array of disciplines. For both reasons, we thought it important to be as explicit as possible about the values that we intend to pursue in implementing the Ph.D. A statement of each value is accompanied by a list of at least some of the aspects of the program that we intend to be primary sites for its implementation. As this list is a “work in progress,” we hope you will both think about the values and suggest ways to refine both the list and additional ways to pursue them.

<b>Value</b>	<b>Program Features that Support It</b>
1. The primary purpose of our Ph.D. program is to <b>educate students who will make original scholarly contributions</b> to the emerging field of informatics.	<ul style="list-style-type: none"> <li>• The broad faculty that we have assembled</li> <li>• The program, including its course requirements, into which you have been accepted</li> <li>• The high accessibility of the other, excellent educational resources of Indiana University</li> </ul>
2. Central to achieving this primary objective is <b>respect for and interest in creating scholarly work of the highest standard</b> , respect and interest both being sensibilities that are important to successful professional careers.	<ul style="list-style-type: none"> <li>• The research culture that we are creating in the School</li> <li>• The general program requirements</li> <li>• The annual faculty evaluations</li> <li>• The frequent public presentations of student work</li> <li>• The several means of support for both student and faculty participation in scholarly conferences, workshops, and training</li> </ul>
3. We place high value on <b>learning by doing</b> , in regard to both what	<ul style="list-style-type: none"> <li>• The required research rotations with diverse faculty</li> </ul>

<p>goes on in the classroom and in a deep and continuous exposure to and involvement in the actual research process.</p>	<ul style="list-style-type: none"> <li>• The opportunities to work with faculty on their research</li> <li>• The research projects required in courses</li> <li>• The dissertation project that each of you will complete</li> <li>• The summer internship option</li> </ul>
<p>4. We view informatics as a profoundly <b>interdisciplinary</b> endeavor.</p>	<ul style="list-style-type: none"> <li>• The relatively heavy course requirements that promote deep knowledge of areas beyond the student's sub-field</li> <li>• The system of postponing formation of dissertation committees until completion of at least two rotations</li> <li>• The inducements which we have instituted to promote cross-disciplinary projects among our faculty</li> <li>• Course selections in both the major and minor that enable a degree of choice within specialization</li> <li>• The multiple disciplinary influences built into required courses, as by team teaching</li> </ul>
<p>5. Further, we see <b>collaboration, with a focus on mentoring toward independence</b>, essential to all research, as particularly crucial to an interdisciplinary field like Informatics.</p>	<ul style="list-style-type: none"> <li>• Team projects that will feature heavily in your course experiences</li> <li>• Your research work with faculty, both in and outside of your sub-discipline</li> <li>• Your immediate activity in research upon program entry</li> <li>• Associate instructor positions, which build mastery</li> </ul>
<p>6. Successful collaborative research and education in turn depend upon <b>learning environments and experiences which students and faculty create together</b>, based on each bringing substantial resources to the program.</p>	<ul style="list-style-type: none"> <li>• The ability of students to change their program adviser, with the consent of the new adviser</li> <li>• Students' own selection of dissertation chair and committee, again with the consent of all involved</li> <li>• Substantial student participation in program governance, both within the School of Informatics and the Indiana University Graduate School</li> <li>• Evaluation modalities, such as take-home exams and portfolio analysis, that aim to</li> </ul>

	minimize anxiety
7. An <b>ability to teach well</b> , in either formal or informal contexts, or both, is also an important skill for the Ph.D. informatician.	<ul style="list-style-type: none"> <li>• The required course on pedagogy</li> <li>• The modeling of good teaching promoted among our faculty</li> <li>• Students' experiences as Associate Instructors (AIs)</li> <li>• Promotion of involvement in the IUB learning community</li> </ul>
8. Since Informatics is a new field, it is especially important that its first Ph.D.s are committed to <b>servng the profession</b> .	<ul style="list-style-type: none"> <li>• Support for student clubs and organizations</li> <li>• Program support for service to the university and the profession among faculty and staff</li> <li>• Faculty and staff who individually and collectively take active, even leadership roles and positions in organizations promoting Informatics</li> </ul>
9. Finally, since our ideas regarding what Informatics is will doubtless change as the field develops, and since there may well be specific situations in which values articulated above conflict with one another, we need to approach program implementation with some <b>humility and, where justified, a degree of flexibility</b> .	<ul style="list-style-type: none"> <li>• Our adoption of an iterative approach to program design</li> <li>• Our active governance procedures that include student involvement</li> </ul>

## **Advising**

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Students admitted to the Ph.D. Program are assigned a **program chair** who may be consulted for advice. The Associate Dean for Graduate Studies and Research as well as the Director of Graduate Programs is also available for general consultation. The student may change adviser upon the consent of the new faculty person and the Associate Dean. The student must inform the existing adviser that a switch has been made. This adviser is the chair of the student's program committee.

By the end of the end of the first year of his/her program, each student will consult with appropriate faculty members and designate, with their consent, members of a suitable program committee to oversee and conduct the qualifying exam in the student's research area. The program committee must by University Graduate School rules include at least two members from the student's major area, and at least one from another area; at least two must be members of the graduate faculty. The names of the committee members presented by the student will be

forwarded to the University Graduate School upon approval by the Associate Dean for Graduate Studies and Research in the School of Informatics.

The program committee oversees the student's progress until the passing of the qualifying examination, whereupon the student consults with the committee concerning a thesis supervisor. When the student has a thesis adviser, the student and adviser designate, with their consent, members of a suitable dissertation committee (the program committee is abolished).

The members of the dissertation committee must meet the requirements of the University Graduate School: the committee includes the director, normally the professor directing the dissertation, two or more additional faculty members from the same department, and a representative of each minor; with certain exceptions, the members must belong to the graduate faculty. This committee supervises the dissertation research, conducts the thesis proposal examination, and conducts the Ph.D. thesis defense final examination.

### **Research Group Rotations**

Each student will engage in research rotations during the first two to three semesters of the program. The student is required to engage in two research rotations (three credits each for a total of six credits) and may engage in a third rotation although no course credit will be given. The student chooses an Informatics faculty person with whom to study for one semester. The faculty person integrates the student into his/her research group/program **and the student and faculty person create a formal agreement of goals consistent with the research area for the student to achieve during the rotation.** Minimally, the student will engage in readings and apprenticeship work with the faculty and other students in that group. The goal is to engage in research with the faculty person (typically at a beginning level) and to decide if this person is a potential thesis adviser for the student's dissertation work.

### **Annual Reviews**

Each year, graduate students will be required to file an annual review with their adviser and program or dissertation committee. The review is due on June 1<sup>st</sup>. The annual review covers the period of the previous academic year. Four areas will be included in the report: course work, research, teaching, and service. The exact format will be distributed in the spring semester. The purpose of the annual report is to provide written feedback to the student, including any recommendations or required actions. The feedback will be signed by the student's committee chair as well as by the Associate Dean for Graduate Studies and Research.

## Curriculum

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### *Credit Hours:*

A total of 90 credit hours will be required for this degree. No more than 30 of those hours would be counted from a master's degree taken at Indiana University or a graduate program at another university. (An additional 6 hours of master's thesis or capstone project may be counted toward the Ph.D. at the discretion of the student's program committee, assuming the thesis or capstone project is of sufficient research quality.) The 90 credit hours will consist of:

- 27 hours of required Informatics courses:
  - I501 3 hours
  - Core: 9 hours
  - Seminars: 6 hours
  - Professionalism/Pedagogy 3 hours
  - Research Rotations 6 hours
- 12 hours in theory and methodology courses
- 21 to 30 hours in electives
- 21 to 30 hours for dissertation work

**Required Informatics courses (27 hours).** Three hours as an informatics introduction core course (I501) will be required of all students. An additional 9 hours (3 courses) will also be required in informatics courses in subdisciplines ("tracks") outside of the track being pursued by the student. Six hours of seminars in the student's subdiscipline (track) will be taken in the school. One 3 hour Graduate School required course in professionalism and pedagogy will be required to prepare students for entry to careers in industry or academia. Additionally, 6 hours (2 courses) of research rotation will be required.

**Theory and Methodology (12 hours).** Twelve credits of theory and methodology applicable to the student's specialty in informatics will be selected from courses both inside and outside the school.

**Electives (21 to 30 hours).** Additional elective courses could be taken outside the school. These would be in disciplines related to bioinformatics, chemical informatics, health informatics, social informatics, or human-computer interaction. A student could include a minor among these courses in a related field to be approved by the student's program committee.

For students planning to focus on bioinformatics or chemical informatics, a high level of computer programming competence would be required. Students focusing in health informatics would be expected to have a background in one of the health care professions. Students planning to specialize in social informatics or human-computer interaction should have familiarity with design principles and have some grounding in the social sciences.

**Dissertation (21 to 30 hours).** The remainder of hours to total 90 will be used for dissertation credits.

### *Minor:*

All students will be required to have an appropriate minor outside or partially inside the school.

Minors will be selected with the adviser's recommendation. The selected minor should be appropriate to the student's choice of subdiscipline (track) within informatics. Some appropriate minors would include biology, chemistry, cognitive psychology, computer science, history and philosophy of science, information science, or sociology. In all cases the number of hours to be included in the minor will be consistent with the requirements of the unit granting the minor. Some of the courses included in the minor may also count towards the student's methodology or other requirements.

**Grades.** An overall B (3.0) average for all Ph.D. courses in Informatics is required. Any course for which the student receives a grade of incomplete must be completed by the end of one year or the grade will automatically become an F; extensions will be given by the Associate Dean for Graduate Studies only in extraordinary circumstances.

## **Program Description**

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### *Description of program and its objectives:*

The Ph.D. in informatics will encompass a range of informatics-based options for the student. Informatics is an integrated multidisciplinary field. The doctoral program will provide a balance between technological, scientific, and social dimensions involved in the development and application of information technology.

Whatever the specific focus of their informatics doctoral study, students will draw on course work taken from several disciplines. In the science informatics areas, the degree is built on a base of advanced computer programming skills, mathematics, and statistics; and scientific disciplines like molecular biology for bioinformatics and organic chemistry for chemical informatics. Knowledge acquired from the integrated study of these areas is applied to research topics related to the storing, retrieving and analyzing of data in the fields of bioinformatics and chemical informatics.

For the student interested in health informatics, the program offers the resources of one of the largest academic health centers in the country. The School of Informatics works closely with the School of Medicine (collaboration in and support of bioinformatics, primarily in the Center for Computational Biology and Bioinformatics), School of Nursing (faculty appointments in the Health Informatics Graduate Program, dual curricular development), and School of Health and Rehabilitation Sciences (Health Education for the 21<sup>st</sup> Century Project). The School also collaborates with the Regenstrief Institute, one of the premier research centers for medical informatics, located on the IUPUI campus.

For the student interested in human-computer interaction, the multidisciplinary program brings together computer prototyping skills, behavioral science theory, and design principles to allow the student to address research topics related to the design, evaluation and implementation of interactive computing systems in social settings. For the student interested in social informatics, the program offers a combination of knowledge of computing with the interdisciplinary study of the uses and consequences of information technologies that takes into account their interaction with institutional and cultural contexts.

We anticipate that several different tracks in the degree will be added as the school evolves. Any new tracks of the Ph.D. would carry the same core requirements as those outlined here. Any new tracks must be approved by the Graduate Council and vetted through the University.

***Admission requirements, anticipated student clientele, and student financial support:***

Admission requirements in the areas of undergraduate grade point average and GRE score levels are those of the University Graduate School. We also require the student to have some skill in computer programming. The student who expects to pursue a specialization in the science informatics areas will need to have excellent programming skills, but can acquire some of that skill in the program. Some basic skill level is needed for all doctoral applicants, however. Currently the requirement for entry to the master's degree in bioinformatics requires at least six undergraduate credit hours of computer science or informatics coursework that covers areas of programming, discrete structures and data structures. These requirements would be the same for anyone entering the Ph.D. program focused on science informatics with an undergraduate background.

The School has established a policy for students who request accommodations in their programs indicating that it is incumbent upon the student, when applying for the Ph.D. program, to outline how the proposed accommodations will provide an education which is substantively equivalent to the "standard" one – that is, the one experienced by those pursuing the Ph.D. in the typical manner.

Students with professional experience will be encouraged to apply. Since the program seeks to prepare students to enter careers in academia where professional degrees will be offered, it is important that students have experience in the field they will prepare others to enter.

***Qualifying examinations - written (required):***

All students will take a written qualifying examination that consists of a *depth exam* and a *breadth exam*. The qualifying examinations are described in a separate document. Examinations will be offered at the end of August and at the beginning of the second semester in January. Examinations must be completed by the beginning of the student's fourth year in the program but can be completed before that time when the core courses are completed. Students who do not successfully complete the examination can retake the exam a second time.

***Qualifying examinations - oral (required):***

The oral qualifying examination covers in-depth knowledge of the student's primary research area. This examination is administered by the student's program committee.

The qualifying examinations will normally be completed at the end of course work, before the student embarks on the dissertation. The student must pass this examination before passing on to candidacy.

***Dissertation proposal:***

The research proposal for the dissertation must be approved by the student's research committee. That committee may have the same membership as the program committee or the student may choose different members. The adviser for the dissertation will be a faculty member in the

School of Informatics and a member of the Graduate Faculty. At least one of the three other members of the committee will be based outside of the school. The student will defend the proposal at a public colloquium in the school.

### **Relationship between Master's and Ph.D.**

The current master's degree is a professional program in these areas: (at IUB) bioinformatics, chemical informatics, and human-computer interaction; (at IUPUI) bioinformatics, chemical informatics, human-computer interaction, health informatics, laboratory informatics, and media arts and science. We anticipate that these programs will continue, perhaps with new areas (such as cybersecurity or music informatics) augmenting the current degrees. Students accepted into the Ph.D. program will be admitted with a bachelor's degree or with a master's degree. Students with master's degrees in informatics will be allowed to apply for admission to the Ph.D.

For those who enter the Ph.D. program directly from their bachelor's program, there will be a formal assessment after two years of coursework, an "up or out" evaluation. For those who wish to enter the Ph.D. program from their master's program, there will be an application process. In this case, there is a natural evaluation of the student's record.