

# Doctor of Philosophy in Informatics

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## 2009 Handbook

The Indiana University School of Informatics and Computing<sup>1</sup>, the first of its kind in the United States, 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.)

### 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 tracks in the Informatics Program:

- **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, and computational intelligence.
- **Health Informatics** (IUPUI and in a formative stage at IUB)  
Electronic health records, health data exchange, standards and terminology for health data, clinical decision support, consumer health informatics, technology to enhance patient safety, health application development and implementation, ontologies, mining clinical data, and

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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. In July 2009, the school was renamed to the School of Informatics and Computing. The Ph.D. in Computer Science follows the policies specified by the Computer Science faculty and the University Graduate School. The Ph.D. in Informatics follows the policies described in this document and the University Graduate School.

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, and design pedagogy.
- **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, and music information retrieval.
- **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, privacy, security auditing, security and computer forensics.
- **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 track (listed above); courses in methodology and theory; electives in related disciplines inside and outside of the School leading to a Ph.D. Minor; and a dissertation. Students will be encouraged to pursue internships as part of the elective courses or independent studies of their program.

## **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

Ours is the first Ph.D. program (in the U.S.) to carry the label “Informatics.” For this reason as well as the diversity of our faculty, 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.

Value	Program Features Supporting the Value
<p>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.</p>	<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>
<p>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.</p>	<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>
<p>3. We place high value on <b>learning by doing</b>, in regard to both what 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 required research rotations with diverse faculty</li> <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> </ul>
<p>4. We view informatics as a profoundly <b>interdisciplinary</b> endeavor.</p>	<ul style="list-style-type: none"> <li>• The 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</li> </ul>

	<p>least two rotations</p> <ul style="list-style-type: none"> <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 advisor, with the consent of the new advisor</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 and the Indiana University Graduate School</li> <li>• Evaluation modalities, such as take-home exams and portfolio analysis, that aim to minimize anxiety</li> </ul>
<p>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.</p>	<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>
<p>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>.</p>	<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>

<p>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></p>	<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>
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## **Advising**

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

No later than one year after admission to the Ph.D. program, each student will consult with appropriate faculty members and designate, with their consent, members of a suitable advisory committee. The advisory committee will guide the student's doctoral program as well as oversee and conduct the qualifying exam in the student's research area. The advisory 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 DGP for the Informatics program.

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

The members of the research 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 School, 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**

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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 **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 director for the student's dissertation work.

## Annual Reviews

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Each year, graduate students will be required to file an annual review with their advisor and advisory or research 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 DGP.

## 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 advisory 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 "Introduction to Informatics" 3 hours
  - Three Ph.D. core/breadth courses outside the student's track 9 hours
  - Two advanced research seminars within the student's track 6 hours
  - Two Research Rotations 6 hours
  - I600 (or equivalent) "Professionalism/Pedagogy" 3 hours
- 33 to 42 hours in theory, methodology and elective courses or independent study, decided by advisory committee with student
- 21 to 30 hours for dissertation work

Required Informatics courses (27 hours). Three hours as an informatics introduction core course (I501) are required for all students. An additional 3 breadth core courses (9 hours) are also required. These are breadth courses in subdisciplines ("tracks") outside of the track being pursued by the student. Six hours of advanced seminars in the student's track are also required to develop depth proficiency in the field. One 3 hour Graduate School required course in professionalism and pedagogy or equivalent is required to prepare students for entry to careers in industry or academia. Finally, 6 hours (2 courses) of research rotation with faculty chosen by the student are also required.

Theory, Methodology, and Electives (33 to 42 hours). The breakdown of theory, methodology and elective courses are to be decided by the student's advisory committee. These can also be more research oriented independent studies.

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

*Minor:*

All students are required to have either an approved minor outside of Informatics or pursue a minor inside the School. Internal and external minors should be appropriate to the student's research as determined by the student's advisory committee. Some appropriate minors would include biology, chemistry, physics, cognitive science, computer science, history and philosophy of science, information science, law, sociology, or learning sciences. In all cases the number of hours to be included in the minor is consistent with the requirements of the unit granting the minor.

In the case of an **internal minor**, students may choose from one of eight internal school minors. Minors in Computer Science, Bioinformatics, HCI, and Social Informatics are currently advertised in the *University Graduate School Academic Bulletin*. Please refer to the bulletin regarding the requirements for each.

Four additional internal minors exist in Complex Systems, Music Informatics, Security Informatics, and an Individualized minor. Ph.D. students inside the School may obtain a minor in one of the four distinct areas by completing nine credit hours of course work from courses listed 500 and above. The course prescription for the minor must be approved by the Director of Graduate Programs under recommendation from the student's advisor. The average grade point for the minor must be at least a B (3.0) or above, and no course grade below a B- (2.7) is counted toward the minor.

To be used for graduate credit, 300 and 400 level courses must receive prior approval by the University Graduate School. See the *University Graduate School Academic Bulletin* for more details.

*Classes for the internal minors* (the descriptions for Bioinformatics, Computer Science, HCI, and Social can be found in the *University Graduate School Academic Bulletin*):

Complex Systems

Both I609 and I709 are required. The student may choose among the remaining courses to obtain the degree. In consultation with both the Area Director and advisor, additional classes can be counted toward the degree.

- I609 Advanced Ph.D. Seminar in Complex Systems I (3 cr.)
- I709 Advanced Ph.D. Seminar in Complex Systems II (3 cr.)
- I585 Biologically-inspired Computing (3 cr.)
- I586 Artificial Life as an Approach to Artificial Intelligence (3 cr.)
- I601 Introduction to Complex Systems (3 cr.)
- I690 Mathematical Methods for Complex Systems (3 cr.)

### Music Informatics

- I545 Music Information, Search, and Retrieval (3 cr.)
- I546 Music Information Processing: Symbolic (3 cr.)
- I547 Music Information Processing: Audio (3 cr.)
- I548 Music Information Processing: Audio (3 cr.)

### Security

In consultation with both the Area Director and advisor, CS649 (Networking Security) and CS649 (Trusted Computing) may be substituted for any two of the courses. The minor is obtained from the following list of classes:

- I533 Protocol Analysis and Design (3 cr.)
- I537 Social Information Security (3 cr.)
- I599 Malware (3 cr.)
- I536 Cryptography (3 cr.)
- I525 Economics of Security (3 cr.)

### Individualized Informatics

Upon consultation with the Associate Dean of Graduate Studies and Director of Graduate Programs with recommendation by the student's advisor, a suite of classes 500 and above can be obtained for an Informatics minor. The courses taken must include I501: twelve (12) credits for an external and nine (9) for an internal degree.

To summarize:

There are eight minors for those inside the School. These include the four new minors as described above: Complex Systems, Music Informatics, Security Informatics, and Individualized Informatics, with 9 credits required and fully controlled by the School. Also, there is an existing School Bioinformatics minor already existing requiring 9 credit hours for Informatics students and 12 credit hours for those outside School. There is an existing campus HCI Minor currently headed by school faculty requiring 12 credit hours for School students. There is also an existing campus Social Informatics minor currently led outside School requiring 12 credit hours for School students. Finally, there is the Computer Science minor.

**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 GPD only in extraordinary circumstances.

### **Program Description**

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

The Ph.D. in informatics encompasses a range of informatics-based options for the student. Informatics is an integrated multidisciplinary field. The doctoral program provides 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 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 and Computing 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 user studies, behavioral science theory, new media theory, criticism, 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 new 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 advisory 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 advisory committee or the student may choose different members. The advisor 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, human-computer interaction, and security informatics; (at IUPUI) bioinformatics, chemical informatics, human-computer interaction, health informatics, and media arts and science. We anticipate that these programs will continue, perhaps with new areas 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.