# ITP Ph.D. Program

## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overview</td>
<td>2</td>
</tr>
<tr>
<td>Course Requirements</td>
<td>2</td>
</tr>
<tr>
<td>Core Course Requirement</td>
<td>4</td>
</tr>
<tr>
<td>Technology Course Requirement</td>
<td>5</td>
</tr>
<tr>
<td>Business/Economic/Policy Course Requirement</td>
<td>5</td>
</tr>
<tr>
<td>Preliminary Exam</td>
<td>6</td>
</tr>
<tr>
<td>Preliminary Paper</td>
<td>7</td>
</tr>
<tr>
<td>Core Proficiency</td>
<td>8</td>
</tr>
<tr>
<td>Preliminary Paper</td>
<td>7</td>
</tr>
<tr>
<td>Comprehensive Exam</td>
<td>8</td>
</tr>
<tr>
<td>Core Proficiency</td>
<td>8</td>
</tr>
<tr>
<td>Ph.D. Course Plan</td>
<td>9</td>
</tr>
<tr>
<td>Semester 1 (Fall)</td>
<td>9</td>
</tr>
<tr>
<td>Semester 2 (Spring)</td>
<td>9</td>
</tr>
<tr>
<td>Summer: work on Preliminary Paper.</td>
<td>9</td>
</tr>
<tr>
<td>Semester 3 (Fall)</td>
<td>10</td>
</tr>
<tr>
<td>Semester 4 (Spring)</td>
<td>10</td>
</tr>
<tr>
<td>Subsequent Semesters</td>
<td>10</td>
</tr>
<tr>
<td>Credit Transfers</td>
<td>10</td>
</tr>
<tr>
<td>Thesis and Final Examination</td>
<td>11</td>
</tr>
</tbody>
</table>
OVERVIEW
This document describes the Doctor of Philosophy (Ph.D.) program in the Interdisciplinary Telecommunications Program (ITP) at the University of Colorado at Boulder.

The ITP Ph.D. program is for highly motivated students seeking to conduct research at the intersection of the telecommunications technology, economics and policy disciplines. The Ph.D. program provides a common set of core courses for all students that serve as the foundation for interdisciplinary research focused on advancing the development and deployment of broadband networking, information technology and communications technologies.

While the core courses teach the necessary skills to conduct Ph.D. research, ITP students take even more classes focused on the specific areas of their research, often mirroring one of the established curriculum tracks in the ITP program such as network engineering, wireless networking, telecom strategy and policy, and network security.

ITP is a unique program and it is suited to Ph.D. students with an interdisciplinary outlook and research interests that span diverse areas in new ways. The students who apply to the Ph.D. program are expected to have already earned a technical undergraduate or graduate level degree, or have substantial work experience in the private or public sectors in the information technology, telecommunications, or multimedia technology fields. We will also consider those students who do not meet these criteria but may obtain an M.S. in ITP as they progress toward a Ph.D. degree. Such an M.S. degree, however, should be viewed only as a necessary step toward the Ph.D. degree. Students wishing to complete only the M.S. degree in ITP should apply directly to the ITP M.S. program and not the Ph.D. program.

Prospective students applying to the ITP Ph.D. program must have a desire to solve interdisciplinary research problems in broadband networking, information technology or communications. ITP provides a unique institutional environment that focuses and nurtures the application of qualitative and quantitative research methodologies on interdisciplinary problems of national and global scale. We seek to unlock substantial innovation by gathering students and faculty from different disciplines to conduct research on pressing technology, economic and policy issues in the broadband networking, information technology and communications arenas.

COURSE REQUIREMENTS
The course requirements for a Ph.D. are designed to provide students with the research skills and knowledge required to conduct interdisciplinary research on current problems in the telecommunications sector. The curriculum contains three categories of required courses: 1) core ITP courses, 2) technology courses, and 3) business/economics/policy courses.

Students are expected to successfully complete a total of at least 60 credits in graduate level courses (i.e., courses taken subsequent to receiving their undergraduate degree) in order to fulfill the requirements for a Ph.D. degree in ITP as shown in the chart below.

<table>
<thead>
<tr>
<th>Minimum Number of Credits</th>
<th>Core Courses</th>
<th>Technology Courses</th>
<th>Business/Economics /Policy Courses</th>
<th>Elective Courses</th>
<th>Thesis Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 credits</td>
<td>6 credits</td>
<td>9 credits</td>
<td>7 credits</td>
<td>30 credits</td>
<td></td>
</tr>
</tbody>
</table>

The following chart outlines the required courses for the Ph.D. curriculum:

<table>
<thead>
<tr>
<th>Category</th>
<th>Course Number</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Required Core Courses</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TLEN7001</td>
<td></td>
<td>Interdisciplinary Telecom Analysis</td>
<td>3 credits</td>
</tr>
<tr>
<td>TLEN7002</td>
<td></td>
<td>Network Analysis Techniques</td>
<td>3 credits</td>
</tr>
<tr>
<td>TLEN5700</td>
<td></td>
<td>Research Methods</td>
<td>2 credits</td>
</tr>
<tr>
<td><strong>Required Technology Courses</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TLEN5310</td>
<td></td>
<td>Telecommunications Systems</td>
<td>3 credits</td>
</tr>
<tr>
<td>TLEN5330</td>
<td></td>
<td>Data Communications 1</td>
<td>3 credits</td>
</tr>
<tr>
<td><strong>Required Business/Economics/Policy Courses</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TLEN5010</td>
<td></td>
<td>Network Economics and Finance 1</td>
<td>3 credits</td>
</tr>
<tr>
<td>TLEN5130</td>
<td></td>
<td>Telecom Business Strategy</td>
<td>3 credits</td>
</tr>
<tr>
<td>TLEN5210</td>
<td></td>
<td>Principles of Telecommunications Policy</td>
<td>3 credits</td>
</tr>
</tbody>
</table>

Some students may choose to earn an M.S. in ITP as a step to obtaining a Ph.D. To
do this they must meet the following minimum requirements:

- Spend at least two academic semesters as a full-time (5 credit hours at minimum) graduate student in ITP
- Complete all required Core, Technology, Business/Economics/Policy courses including the Teaching Practicum (as discussed below)
- Complete an additional 3 credits of Technology courses
- Pass the ITP prelim exams at the M.S. level or better

Students, who already have received an M.S. either from ITP in the recent past (within five years) or from a comparable interdisciplinary program from a recognized accredited university, may be allowed to waive certain Core courses based upon the results of a waiver test or the decision of the ITP Preliminary Examination Committee.

**Core Course Requirement**

The heart of the required Core curriculum is two courses describing qualitative and quantitative research tools for interdisciplinary analysis of network issues. **Interdisciplinary Telecom Analysis (TLEN 7001)** is a course that examines a set of problems, research methodologies, and analytical techniques that are common to the research, problem solving, and analysis of telecommunications technology development and deployment issues. The objective is to look critically at the strengths, limitations and underlying assumptions of key research and analysis tools that relate business, economic and policy objectives to current and future telecommunications technology development and deployment efforts.

**Network Analysis Techniques (TLEN 7002)** is a course that provides a broad introduction to analytical and computational methods commonly used to address telecom technology and networking issues. Particular emphasis is given to optimization techniques employing linear programming, graph theory, and other fundamentals to plan and analyze the deployment and operation of wireline and wireless networks.

Additionally, in their first semester students will take **Research Methods (TLEN 5700)** to acquire basic research skills and experience in creating a research proposal and forming a research team.

To fulfill their teaching practicum, students will serve as a teaching assistant or Instructor for the M.S. level courses in ITP. Teaching Assistant duties include assisting the course instructor in administering the course website, preparing and grading homework and test questions, attending lectures, meeting weekly with the
course instructor to plan recitation sessions, conducting recitation sessions, assisting in assigning grades, and being available outside of class to assist students and answer questions. Instructor duties include preparing a course syllabus, administering the course website, preparing and delivering class lectures, grading homework and tests, and meeting weekly with students during office hours.

Students are expected to fill their teaching practicum requirement by the end of their third year in the program.

**Technology Course Requirement**
Consistent with the ITP M.S. core curriculum, Ph.D. students must take two technology courses, both in the first semester of enrollment. The first, **Telecommunications Systems (TLEN 5310)**, provides an in-depth investigation of fundamental telecommunications concepts and terminology. The course covers the technical architecture and operation of telecommunication systems such as the Internet, telephone networks and wireless systems. The second required technology course is **Data Communications (TLEN 5330)**. This course provides a comprehensive technical survey of data and computer communications including wireless, metropolitan area network and wide area network systems and standards. This course covers the relevant network interfaces, wired and wireless network technologies (e.g., Ethernet, IEEE 802.11), packet switching, routing, and Internet design issues needed to conduct in depth analyses of telecommunications networking problems.

To meet the remaining credits required, students choose from a large group of graduate technical courses in areas such as engineering, science, applied mathematics, and statistics. A core philosophy within ITP is that its students develop a clear understanding of the technical dimensions of the research problems undertaken within the program. The remaining credits required in technology are meant for students to develop the necessary mastery in a specific technical arena, presumably relevant with their intended area of research focus, similar to that obtained in a traditional program of graduate study in that area.

**Business/Economic/Policy Course Requirement**
The interdisciplinary focus in ITP is important, and the curriculum contains three required courses to support this philosophy. **Network Economics and Finance 1 (TLEN 5010)** introduces students to the fundamental theoretical framework and tools used by economists to examine telecommunications business, finance and policy issues. The course provides an introduction to mathematical economics, game theory, and economic concepts common to telecommunication regulation.
TLEN 5130 Telecom Business Strategy considers a telecom services business across its full life cycle, including the business’ strategy, platform, and operations. This course requires students to learn the important business methods and concepts required to scale a business with the urgency required to compete in disruptive markets created by the Internet. Principles of Telecommunications (TLEN 5210) provides a basic introduction to the information and communications policies and regulations governing how telephone, mobile, cable, and Internet providers offer their services to customers. This course examines the justification and approach for the current laws and regulations impacting the telecommunications sector.

To meet the remaining credits required in this category, students are encouraged to choose from graduate classes in economics, political science, regulation, or law. The interdisciplinary focus in ITP places a strong emphasis on selecting courses in the social science, business, and legal disciplines to compliment the core technology courses. Students are expected to demonstrate initiative in selecting those courses in this category that lend strength to the interdisciplinary focus of their research.

Indeed, the ITP curriculum offers students a large degree of flexibility in satisfying the course requirements for a Ph.D. degree. We require students to identify and develop their own research and academic program within their first year at ITP in a customized degree plan. To achieve this, students accepted to the program are assigned academic advisors who review initial course selections and progress each semester against the degree plan. Academic advisors can change as the individual research objectives of the students change with experience in the program. The degree plan should target the student’s core area of interest, and select the courses needed to achieve the necessary knowledge of this area.

A record of the student's degree plan is kept and reviewed each semester to ensure that course requirements are met. Formal review and approval of the degree plan occurs as part of the student's Ph.D. thesis proposal. The review certifies that an acceptable level of mastery of the chosen core area has been attained or additional coursework is needed.

Preliminary Exam
The objective of the ITP Preliminary Examination is to assess the ability of Ph.D. candidates to conduct interdisciplinary research based on sound knowledge of telecommunications technology, economics, and policy. The Preliminary Examination requires students to clearly analyze telecommunications problems in a way that appropriately integrates the required knowledge, research methods, and
academic judgment obtained in required ITP coursework.

The Preliminary Examination consists of two components: a Preliminary Paper and successful demonstration of proficiency of ITP core courses. All students must complete both the Prelim Paper and all ITP core courses by their fourth semester (the Spring semester of their second year unless they have successfully petitioned the ITP Ph.D. Preliminary Examination Committee for an exception by the end of the first month of the Fall semester of their second year).

**Preliminary Paper**

The Preliminary Paper is an original research paper that addresses a problem in telecommunications that includes issues of technology, economics, and public policy. This paper should demonstrate the student's ability to structure and perform research on a telecommunications problem in a straightforward fashion, including the ability to apply formal analytical tools as part of the research methodology.

The paper typically requires one year to prepare in parallel with regular coursework. Students are expected to seek the assistance and supervision of a faculty advisor and other faculty in preparing and conducting research for this paper. Students are expected to demonstrate substantial individual initiative in the process of proposing and selecting their paper topic.

Students must gain approval of the research topic of their Preliminary Paper at the end of their second semester by gaining agreement from three members of ITP faculty to a one-page prospectus, one of who is a member of the ITP Preliminary Examination Committee. The prospectus is then reviewed by the ITP Preliminary Examinations Committee, and distributed to all members of the ITP faculty. Students must deliver a preliminary oral presentation of their paper to ITP faculty at the beginning of the fourth semester.

Students can elect to use a research paper completed prior to joining ITP with the approval of the ITP Preliminary Examination Committee. Such approval is contingent upon the student demonstrating that this work has been fully completed by the student without the assistance of others and was completed after having obtained an undergraduate degree. A master's thesis completed as part of the ITP M.S. degree, or from another recognized M.S. Program, could qualify for this purpose.

The Preliminary Paper, 5,000 words in length or less, must be submitted on a date to be announced in April after the student has been in the program for four
semesters. The Preliminary Paper should be of publishable quality, and students will be expected to submit the paper to relevant conference and journals upon completion. The oral defense occurs in April when the student makes a 30-minute presentation of the paper to ITP faculty. Faculty questions may cover the interdisciplinary and technical aspects of the research paper, as well as the underlying strengths and weaknesses of the research methodology applied.

**CORE PROFICIENCY**

Students in the ITP Ph.D. program need to successfully demonstrate proficiency in all the ITP courses taken during their first two years of study. The courses for which ITP Ph.D. students must demonstrate proficiency include Core courses, Technology Courses, and Business/Economic/Policy courses that are part of the degree plan approved by the ITP Preliminary Examinations Committee.

For the first two years in the program, students are assumed to demonstrate proficiency in these courses by maintaining a GPA of 3.5 or higher, with no single course grade below a B. Students with a GPA in the range of 3.0 – 3.5, or with a single course grade below a B, will be reviewed by the ITP Preliminary Examination Committee. A GPA below 3.0 will lead to immediate dismissal from the program.

**COMPREHENSIVE EXAM**

Students who have passed the Preliminary Examination at the Ph.D. level and completed the required coursework (a total of 30 credits) are eligible to take the Comprehensive Examination the following year, roughly 12 months after the Preliminary Examination. The Comprehensive Exam consists of an oral presentation of a written thesis proposal that is reviewed and approved by the Thesis Committee of the student. The thesis proposal should describe the problem statement, research methodology, proposed research plan, along with a brief review of the background of the topic and summary of early results. The research plan should break down the research into development phases and include a tentative schedule for the completion of each research phase. The thesis proposal should not exceed 20 pages.

The Thesis Committee must consist of five members, of whom at least one must be a regular Boulder campus Graduate Faculty member from outside the ITP faculty. Three of the five members must be ITP Graduate Faculty members. ITP faculty members eligible to chair or serve as a PhD committee member must meet the professional and academic qualifications as identified by the Director of the Interdisciplinary Telecom Program and whose permissions are conferred in
compliance with the Graduate School appointing rules. Faculty member committee permissions will be noted in their web biographies. The role of thesis committee members is to assist the research effort and evaluate its progress and quality.

The Comprehensive Exam provides an opportunity for the Thesis Committee to conduct a detailed discussion of the proposed research between the student and thesis committee. The student should plan the length of the thesis proposal presentation to be 45 minutes. Thereafter, the student should plan to consult with all Thesis Committee members on a regular basis to keep them notified of research progress and to provide assistance as requested. In case of failure, the Comprehensive Examination may be attempted once more after a period of time determined by the Thesis Committee.

A student will have earned at least four semesters of residence credit and have passed the Comprehensive Examination before he/she may be admitted to candidacy for the Ph.D. degree in ITP. The student must be registered at the University for the fall and spring semesters each year between the passing of the comprehensive examination and the completion of the dissertation defense. After passing their comprehensive exams, doctoral students are not allowed to go on the Time Off Program.

Students should review the Graduate School website regarding additional rules relative to the comprehensive examination, particularly regarding time limitation.

**PH.D. COURSE PLAN**

**SEMESTER 1 (FALL)**
- TLEN7001 Interdisciplinary Telecom Analysis
- TLEN5010 Network Economics and Finance 1
- TLEN5310 Telecommunications Systems
- TLEN5330 Data Communications 1

**SEMESTER 2 (SPRING)**
- TLEN5310 Telecom Business Strategy
- Course Elective
- TLEN8990 Doctoral Dissertation
- May Approval of Prospectus for Preliminary Paper

**SUMMER: WORK ON PRELIMINARY PAPER**
SEMESTER 3 (FALL)

- TLEN5210  Principles of Telecom Policy
- TLEN5700  Research Methods
- TLEN7002  Network Analysis Techniques
- TLEN8990  Doctoral Dissertation

Course Elective

SEMESTER 4 (SPRING)

- January  Presentation of Progress on Preliminary Paper
- April    Oral Defense of Preliminary Paper
- TLEN8990  Doctoral Dissertation

Course Elective

SUBSEQUENT SEMESTERS

- TLEN 8990  Doctoral Thesis Credits

PhD students are limited to taking only up to 10 TLEN 8990 Doctoral Dissertation credits prior to passing the Comprehensive Exam.

CREDIT TRANSFERS

Up to 21 credits from an outside institution may be applied to the ITP Ph.D. requirements as long as these credits:

- Have been earned from courses taken at a graduate level from a recognized and accredited graduate school,
- Have at least a grade of B (Note: the student's GPA will not be calculated using these transfer credits),
- Were earned within the past 5 years. This time limit may be excused if credits earned from classes taken more than 5 years earlier are evaluated and found acceptable by the ITP Preliminary Examinations Committee,
- Were not applied to an alternate graduate degree of the same level.

Ph.D. credit transfer requests will not be processed until the student has successfully passed the preliminary exam.

If the student has completed a Masters level degree from the University of Colorado, all of those credits may be applied to the PhD coursework, provided they meet both the above requirements as well as the requirements of the degree.
Credit Transfer Form

**THESIS AND FINAL EXAMINATION**

A thesis based upon the research work done with consulting advice from the student's Thesis Committee should be made available to the Thesis Committee at least two weeks before the student takes the final examination. The thesis must conform to the format requirements as set forth by the Graduate School: [http://www.colorado.edu/GraduateSchool/academics/thesis_sub.html](http://www.colorado.edu/GraduateSchool/academics/thesis_sub.html).

The student is responsible for arranging a final examination with the members of the Thesis Committee. The student is responsible for notifying the Graduate School as well as the ITP Office of the final examination date a minimum of two weeks in advance of the test date. The candidate must be a registered student at the time of the final examination.

Following the semester in which the comprehensive exam is passed, the student must be continuously registered each fall and spring for dissertation hours until the student successfully defends his or her dissertation or formally withdraws from the program. These students are required to either register for at least 5 credit hours per semester of dissertation research on campus, or for at least 3 credit hours per semester if dissertation research takes place off campus (distance). However, off-campus status is considered part-time enrollment and does not allow for Research Assistant (RA) or Teaching Assistant (TA) appointments.

Registration during every fall and spring semester is mandatory for all students who have passed the comprehensive exam until all requirements for the degree are completed. Summer enrollment is required only if the Final Examination for the thesis is during the summer term.

In general, all graduate students at the University of Colorado Boulder are subject to the guidelines and requirements specified in the [*Graduate School Rules*](http://www.colorado.edu/GraduateSchool/academics/thesis_sub.html).