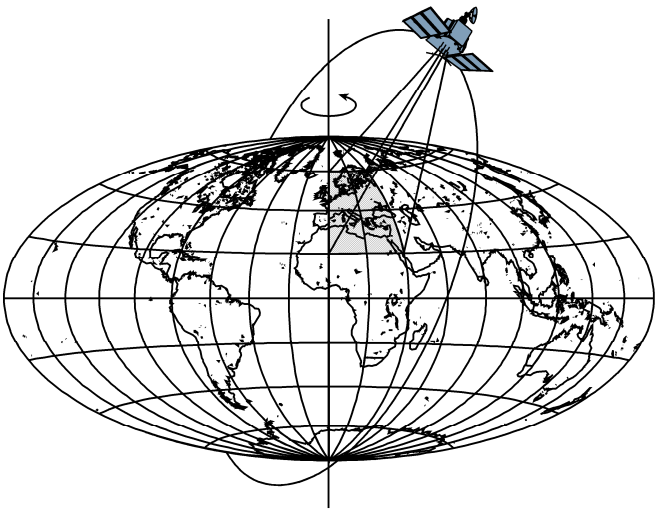
Geodetic Science

Program and Course Offerings



Division of Geodetic Science
School of Earth Sciences
Ohio State University

275 Mendenhall Laboratory
125 South Oval Mall
Columbus, OH 43210
tel: 614-292-2721

http://geodeticscience.org

Geodetic Science Graduate Degree Program

I. What is Geodesy?

Geodesy is the science of determining the size and shape of the Earth (including its temporal variation) using measurements primarily (today) of distance, time, and gravity. Being one of the oldest sciences, with a history of more than two thousand years, the traditional measurements were mostly associated with land surveying (distance and direction measurements of landmarks and celestial objects) and gravity observations (to determine the geoid, as reference surface for heights, and the plumb direction). The age of satellites, radio and optical science, and computer technology have completely transformed these methods and enabled geodesy to branch into many of the Earth sciences where the exquisite measurement precision has enabled observations of ocean circulation, terrestrial hydrology, tides, solid Earth deformation, tectonic plate motions, ice sheet mass change, ionospheric and atmospheric changes, Earth rotation variation, and other geodynamical phenomena with unprecedented detail and accuracy. Contemporary geodesy utilizes the latest in mathematical modeling, research in physics, astrometry, scientific computations, and statistical analysis to aid in the understanding of ocean currents, sea level rise, the world's hydrological cycles, atmospheric conditions, global climate change, post-glacial rebound, and elastic deformation, particularly as it relates to natural hazards, such as earthquakes, volcanoes, and flooding. In these Earth science applications, accurate terrestrial reference frames, high-resolution global gravity models, and precise time keeping are of paramount and fundamental importance. Geodesy, of course, continues the tradition of forming the backbone for all national and international datums and reference systems needed to establish three-dimensional positional control of regional and global networks of terrestrial points, as well as the world's civilian and military satellite missions to the Earth and beyond. Many geodetic principles and techniques also have found application in studies of the Moon, other planets, and their satellites.

II. Geodetic Science M.S. Degree

The overall goal of the Graduate Degree Program in Geodetic Science is to provide students the opportunity to gain an advanced education in Geodetic Science. Specific objectives of the program include participation in advanced classes and seminars and, for the M.S. thesis option, to conduct independent research on fundamental problems in Geodetic Science. The products of M.S. research projects are expected to be suitable for publication in the scientific literature.

The M.S. program in Geodetic Science traditionally has focused on the thesis-based M.S. degree; however, there is also an approved Non-Thesis Option (Plan B). The Non-Thesis Option is intended for geodetic scientists in government or industry who do not plan to continue for a Ph.D., and therefore do not require significant preparation in independent research, but whose career paths will benefit from additional educational and practical experience.

Both the M.S. Thesis and Non-Thesis options require a minimum of 30 semester credit hours. Core courses are selected in 4 general categories, where some selections are mandatory and others are elective. Three pre-approved tracks of core courses are available, in the areas of Geodesy, GIS, and Geodynamics. For the M.S. Non-Thesis Option, there is greater emphasis on completing graded courses than in the Thesis Option. However, the Non-Thesis M.S. student is

required to write a technical report, as well as a comprehensive examination in accordance with Graduate School rules.

A. Expected Background

All Master's degree aspirants are expected to have a Bachelor's degree, and they normally will have a degree in the sciences or engineering. The basic entrance requirements to the program include courses in advanced calculus, linear algebra, and introductory physics, and some knowledge of and experience with scientific computer programming using a high-level language. Matlab, C++, Java, and FORTRAN are some of the most commonly used computer programming languages in geodetic science. Completion of the Graduate Record Exam (GRE) is recommended for applicants wishing to be considered for graduate research appointments; and it is required for applications to university academic fellowships or financial assistance thereof (such as tuition waivers).

B. Program of Study

In consultation with the student's advisor, and with approval of the Graduate Studies Committee (GSC), a student will design a course of study appropriate to the field of specialization. If needed, in consultation with the advisor, and with approval of the GSC, students will design a course of study to remedy program deficiencies, to bring the student to the level required to do work in the field of specialization. Students should plan on completing all deficient course work with a grade of "B" or better within one year of entry into the program.

If necessary, the Chair of the Graduate Studies Committee will provide advice on coursework and help in the selection of a research area (Thesis Option) and an advisor. By the end of the first semester in the program every student is strongly encouraged to have identified a research area (Thesis Option) and to have obtained the consent of a faculty member to serve as an advisor. Until the student has an advisor, the chair of the GSC will act in that capacity.

Once a faculty advisor has been identified, the graduate student, in consultation with his/her advisor, will define the curriculum of study and a research topic of appropriate level and scope (Thesis Option). At least one additional faculty members will be identified to serve on the student's Advisory Committee and Master's Examination Committee, subject to approval by the Geodetic Science GSC.

C. Coursework in Geodetic Science

For the M.S. in Geodetic Science a minimum of 30 graduate semester credit hours is required. Of those 30 graduate semester credit hours, approximately 16-24 semester credit hours are earned by completing 4 to 6 courses from 4 core areas; these courses cover basic knowledge and analytic skills required of all M.S. students in the Geodetic Science program. The remaining credit hours are fulfilled with elective courses, including research courses, in one or more areas within Geodetic Science or in related disciplines. Three standard sets of courses are pre-approved to meet requirements within the core areas, as described below. If a student chooses one of these standard sets of courses, then his/her selection of core and elective courses only

requires approval by his/her advisor. Any selection of "core courses" that deviates from these 3 pre-approved sets of courses must be approved by the student's advisor and the GSC.

Except as noted below for one of the pre-approved sets of core courses, a student must complete the 2 foundational courses and 1 course chosen from each of the following 3 categories: Geodetic Science, Geomathematics, and Sensor Systems and Applications.

1. Foundational Courses
a) Geod Sci 5660, Geometric Reference Systems (4 semester credit hours)
b) Geod Sci 5636, Geovisualization Geometry (4 semester credit hours)

2. Geodetic Science
a) Geod Sci 6776, Physical Geodesy (4 semester credit hours)
b) Geod Sci 6777, Satellite Geodesy (3 semester credit hours)
c) Geod Sci 5781, Geodesy and Geodynamics (3 semester credit hours)
d) Geod Sci 6786, Geospatial Data Structures for Computer Mapping and GIS (3 sem. cr. hrs.)
d) Earth Sci 5646, Geodynamics (3 semester credit hours)

3. Geomathematics
a) Geod Sci 5652, Adjustment Computations (5 semester credit hours)
b) Earth Sci 5642, Geomathematical Analysis (3 semester credit hours)
c) Math 5601, Essentials of Numerical Methods (3 semester credit hours)
d) Physics 5300, Theoretical Physics (4 semester credit hours)
e) Stat 6450, Applied Regression Analysis (4 semester credit hours)

4. Sensor Systems and Applications
a) CE 7442, Fundamentals of GPS and Reference Systems (4 semester credit hours)
b) Earth Sci 5781, Gravity Exploration (3 semester credit hours)
c) Earth Sci 5782, Magnetic Exploration (3 semester credit hours)
d) Geod Sci 7745, Inertial Navigation/Positioning Analysis (4 semester credit hours)
e) Earth Sci 5650, Glaciology (4 semester credit hours)
f) Earth Sci 5655, Land Surface Hydrology (3 semester credit hours)

The following Table represents suggested 2-year coursework plans for students specializing in Geodesy, GIS, and Geodynamics. These are pre-approved curricula; however, petitions from the student and his/her advisor for deviations in these plans will be considered for approval by the Graduate Studies Committee.

	Geodesy	GIS	Geodynamics*
Autumn Semester, Year 1	GS5636, GS5652, GS5660 Total = 13 credits	GS5636, GS5652, GS5660 Total = 13 credits	GS5636, GS5652, GS5660 Total = 13 credits
Spring Semester, Year 1	CE7442, GS6776, GS6777 Total = 11 credits	GS6786 Other courses Total = $\geq$ 8 credits	GS5781, CE7442 Other courses Total = $\geq$ 8 credits
Subsequent Semesters	Geod Sci or other electives + research credits	Geod Sci or other electives + research credits	Geod Sci or other electives + research credits

* Because this track tends to engage the students more deeply in the Earth sciences, it is common that the core selections in the Foundational Category 1 deviate from the prescribed ones.

D. Thesis Option ("Plan A")

The *Application to Graduate* form must be submitted to the Graduate School for the semester in which the student wishes to graduate, according to the rules of the Graduate School. The final Master's Examination cannot be scheduled until the Advisory Committee has given preliminary approval of the thesis document.

Each student must complete a Master's thesis, which describes the results of an original research project. The thesis document must be prepared according to the guidelines described in the Graduate School handbook.

Upon completion of the Master's thesis, candidates for the M.S. degree must complete a final oral examination, which may include questions on both the thesis research and aspects of the M.S. degree preparation not necessarily related to the thesis. The Master's Examination Committee consists of the Advisory Committee as originally constituted, although substitutions may be approved by the GSC in situations where a member cannot be present at the time of the examination. The advisor serves as chairperson of the examination. The final oral examination will be scheduled and conducted according to the rules of the Graduate School.

E. Non-Thesis Option ("Plan B")

In addition to the core course requirements for the Thesis Option, the Non-Thesis-Option student must complete a minimum of 7 additional semester credits of graded graduate-level coursework

in Geodetic Science or other approved areas, chosen in consultation with his/her advisor, as part of the completion of a minimum of 30 graduate semester credit hours.

The student must also write a 3000–5000 word technical paper on an approved topic, chosen in consultation with his/her advisor, and must orally present it satisfactorily prior to the written Master's Examination. This oral presentation will be evaluated by the student's advisor and one other faculty member, approved by the Geodetic Science Graduate Studies Committee, who usually is also on the Master's examination committee.

The Master's Examination for the non-thesis option (Plan B) is a written, comprehensive examination covering material presented in the required courses. Questions will be written and evaluated by the student's advisor and one other faculty member, approved by the Geodetic Science GSC. The student must successfully complete the Master's Examination to receive the M.S. degree.

F. Awarding of the M.S. Degree upon Completing the Ph.D. Candidacy Examination

In general, the M.S. degree is also awarded (if it has not been earned through a formal curriculum as described above) upon the successful completion of the Ph.D. Candidacy Examination.

G. Transition Plan

Students who began their degree under quarters will not be penalized as we move to semesters, either in terms of progress towards their degree or their expected date of graduation. Arrangements will be made for individual students on a case-by-case basis by their advisors and the Graduate Studies Committee within Geodetic Science, but we anticipate few complications because few of our courses are contained in sequences.

Because our M.S. degree requirements are specified in terms of a required number of credit hours, rather than a required number of courses, credit hours will serve as the "currency" during the transition. Students who have completed graded coursework under quarters will be allowed to count the equivalent number of semester credit hours toward their degree requirements. Students who have completed the quarter equivalent of a pre-approved semester "core course" will be considered to have fulfilled that semester-course requirement; students who have completed quarter courses that are not included in the new pre-approved "core courses" will apply the semester-equivalent credit hours toward their electives.

III. Geodetic Science Ph.D. Degree

The overall goal of the Ph.D. Degree Program in Geodetic Science is to provide students the opportunity to develop advanced research techniques in Geodetic Science. Specific objectives of the program include providing opportunities for students to participate in advanced classes and seminars and to conduct advanced, independent research on fundamental problems in Geodetic Science. The products of the Ph.D. research are expected to be suitable for publication in the refereed scientific literature.

The Ph.D. degree is a research degree, so most coursework is taken during the first 2-3 years. Usually only advanced seminars or pertinent courses that are offered infrequently are taken after that time. The purpose of the coursework in the Ph.D. program is threefold:
1) to prepare students to complete the Ph.D. candidacy exam (which should be completed no later than the end of the student's third year in the program);
2) to prepare students to undertake significant original research in Geodetic Science, culminating in the Ph.D. dissertation; and
3) to prepare students for a long and productive career in the diverse field of Geodetic Science.

A. Expected Background

Students entering the Geodetic Science Graduate Degree Program with the goal of attaining the Ph.D. degree must meet all entrance requirements for the M.S. degree (see I.A.) and generally have obtained a M.S. degree (thesis option) in an equivalent discipline. In some cases, a student may be admitted directly to the Ph.D. program with approval of the Graduate Studies Committee. A Ph.D. student is responsible for knowledge and competency at the M.S. level in Geodetic Science or a related field, and the core courses of the Ph.D. curriculum are designed to prepare for the general examination that will allow the student to become a candidate for the Ph.D. degree. It is recommended that students applying directly to the PhD program and wishing to be considered for graduate research appointments should complete the Graduate Record Exam (GRE); it is required for applications to university academic fellowships or related financial assistance (such as tuition waivers).

B. Program of Study

Each Ph.D. student will meet with, or correspond with, a potential advisor either during the application process or within the first semester of enrollment. Possible research topics will be discussed at this time. A student will be considered to have an advisor when both the student and the potential advisor have agreed to establish this relationship, and it has been approved by the Geodetic Science GSC. If necessary, the Chair of the Geodetic Science GSC will serve as interim advisor, and will assist the student in finding an advisor. The advisor and the student will choose additional faculty members to serve on the Ph.D. Advisory Committee, subject to approval by the GSC.

The student's research topic will be identified by mutual agreement of the student and advisor, subject to approval by the other members of the Ph.D. Advisory Committee and the Geodetic Science GSC. To formalize this agreement, the student will write a Dissertation proposal after

completing the Ph.D. Candidacy Examination; the Dissertation proposal will be approved by the student's advisor and the other members of his/her Ph.D. Advisory Committee, and will be filed with the Geodetic Science GSC.

At the time of the Ph.D. Candidacy Examination, the student is responsible for the knowledge and competencies developed during the Geodetic Science M.S. program, as well as those developed in the core courses of the Ph.D. curriculum.

C. Coursework in Geodetic Science

A minimum of 80 graduate semester credit hours beyond the baccalaureate degree is required for the Ph.D. degree. Students may apply 30 semester credit hours (20 hours of graded coursework plus 10 research hours) earned as part of a Master's degree toward the 80 semester hours, according to the rules of the Graduate School.

For the Ph.D. in Geodetic Science, the student must complete a minimum of 10 credit hours of letter-graded, advanced courses from the list below, or from available advanced courses in the Earth Sciences or related disciplines with approval of the Geodetic Science GSC. The remaining credit hours may be fulfilled with elective courses (including research and seminar courses). The entire curriculum for a student must be approved by the Geodetic Science GSC before the student begins the Ph.D. Candidacy Examination.

Advanced Geodetic Science Courses for the core requirements of the Ph.D.

GS7763	Advanced Adjustment Computations (4 semester credit hours)
GS7765	Analysis and Design of Geodetic Networks (2 semester credit hours)
GS7837	Computational Cartography (4 semester credit hours)
GS8862	Adjustment Computations for Random Processes (2 semester credit hours)
GS8871	Advanced Physical Geodesy (3 semester credit hours)
GS8873	Advanced Satellite Geodesy (3 semester credit hours)
GS7875	Spectral Methods in Geodesy (3 semester credit hours)

D. Ph.D. Candidacy Examination

A Ph.D. aspirant must pass the Ph.D. Candidacy Examination to be admitted to candidacy for the Ph.D. degree, and must ultimately complete and defend a dissertation that presents the results of an independent, original research project that is a scholarly contribution to the science. All components of these requirements (i.e., the Ph.D. Candidacy Examination, the Ph.D. dissertation, and the Ph.D. oral defense) must be fulfilled to meet the requirements of the Graduate School.

A Ph.D. aspirant who enters the program with an M.S. in Geodetic Science is expected to complete the Ph.D. Candidacy Examination by the end of his/her second year in the program. A Ph.D. aspirant who enters the program without an M.S. in Geodetic Science is expected to complete the Ph.D. Candidacy Examination by the end of his/her third year in the program; the additional time is required for the student to achieve the competencies expected of an M.S. student in Geodetic Science. Some exceptions to this general schedule occur because the student

is involved in extensive field work, or some desired courses are not offered at an appropriate time in the student's plan.

The Candidacy Examination includes both written and oral portions, and begins only after the respective Application has been submitted in accordance with procedures outlined by the Graduate School. The student is responsible for knowledge and competency at the M.S. level in Geodetic Science or a related field, as well as competencies presented in the core courses of the Ph.D. curriculum. The Candidacy Examination is administered by the student's Advisory Committee (Dissertation Committee), comprising the student's advisor and faculty members and/or guest members in accordance with Graduate School rules.

The student becomes a Ph.D. candidate on successful completion of the Candidacy Examination. NOTE: If the final oral exam is not taken within five years of admission to Candidacy, the Candidacy exam must be retaken, as required by the Graduate School.

E. Dissertation and Final Oral Examination

To be awarded the Ph.D. degree, a student must complete a dissertation that presents the results of an independent, original research project that is a scholarly contribution to the sciences. The dissertation document must be prepared according to the guidelines described in the Graduate School Handbook.

A Ph.D. candidate must satisfactorily defend the dissertation research in a Final Oral Examination, and must submit an approved copy of the dissertation to the Graduate School. These requirements must be fulfilled according to the requirements of the Graduate School.

The committee for the Final Oral Examination will meet the requirements set by the Graduate School. It is headed by the Student's advisor and includes the members of the Dissertation Committee (comprising faculty and/or guest members in accordance with Graduate School rules) plus a Graduate Faculty representative appointed by the Graduate School.

The rules and regulations covering the PhD Final Oral Examination are detailed in the Graduate School Handbook. The Geodetic Science GSC adheres to these rules and regulations. The format, principles and policies of the Final Oral Examination in Geodetic Science satisfy the Graduate School's requirements and enable the Ph.D. aspirant to present research results and engage in discussion of these and other topics before an audience of mentors, teachers and the student's peer group, as well as responding to formal questioning by the Examination Committee.

F. Registration Guidelines

A Ph.D. student is generally expected to complete all requirements for his or her degree within five years of the semester following successful completion of the Candidacy Examination.

A student must register for at least one credit hour to maintain office space and to use School and University facilities.

A student must meet Graduate School guidelines for registration during the semester in which any portion of the General Examination is taken, the semester during which the Final Oral Examination is taken, and the semester of expected graduation.

GEODETIC SCIENCE SEMESTER COURSES

Geod Sci 5194	Group Studies (1-6 semester credits)
Geod Sci 5612	Introduction to Geodesy (3 semester credits)
Geod Sci 5636	Geovisualization Geometry (4 semester credits)
Geod Sci 5637	Topics in Mapping (3 semester credits)
Geod Sci 5652	Adjustment Computations (5 semester credits)
Geod Sci 5660	Geometric Reference Systems (4 semester credits)
Geod Sci 5781	Geodesy and Geodynamics (3 semester credits)
Geod Sci 6193	Individual Studies (2-6 semester credits)
Geod Sci 6776	Physical Geodesy (4 semester credits)
Geod Sci 6777	Satellite Geodesy (3 semester credits)
Geod Sci 6786	Geospatial Data Structures for Computer Mapping and GIS (3 sem. cr.)
Geod Sci 7745	Inertial Navigation/Positioning Analysis (4 semester credits)
Geod Sci 7763	Advanced Adjustment Computations (4 semester credits)
Geod Sci 7765	Analysis and Design of Geodetic Networks (2 semester credits)
Geod Sci 7837	Computational Cartography (4 semester credits)
Geod Sci 7875	Spectral Methods in Geodesy (3 semester credits)
Geod Sci 7998	Research in Geodetic Science (1-12 semester credits)
Geod Sci 7999	Research for M.S. Thesis in Geodetic Science (1-12 semester credits)
Geod Sci 8862	Adjustment Computations for Random Processes (2 semester credits)
Geod Sci 8871	Advanced Physical Geodesy (3 semester credits)
Geod Sci 8873	Advanced Satellite Geodesy (3 semester credits)
Geod Sci 8785	Research Principles and Techniques (2-6 semester credits)
Geod Sci 9998	Research in Geodetic Science (1-12 semester credits)
Geod Sci 9999	Research for Ph.D. Dissertation in Geodetic Science (1-12 sem. credits)

Please note that not all courses are offered every year. Several offerings also depend on enrollment. The student should check with corresponding instructors and his/her advisor to ensure that his/her curriculum will be completed in a timely manner.