

# STATISTICS

<b>Graduate Program Head</b>	Murali Haran
<b>Program Code</b>	STAT, ASTAT
<b>Campus(es)</b>	University Park (Ph.D., M.S., M.A.S.) World Campus (M.A.S.)
<b>Degrees Conferred</b>	Doctor of Philosophy (Ph.D.) Master of Arts (M.A.) Master of Science (M.S.) Master of Applied Statistics (M.A.S.) Dual-title Ph.D. and M.S. in Statistics and Operations Research Dual-title Ph.D. in Statistics and Social Data Analytics Integrated B.A. or B.S. in Mathematics and M.A.S. in Applied Statistics Integrated B.S. in Statistics and M.A.S. in Applied Statistics
<b>The Graduate Faculty</b>	STAT ( <a href="https://secure.gradsch.psu.edu/gpms/index.cfm?searchType=fac&amp;prog=STAT">https://secure.gradsch.psu.edu/gpms/index.cfm?searchType=fac&amp;prog=STAT</a> ) ASTAT ( <a href="https://secure.gradsch.psu.edu/gpms/index.cfm?searchType=fac&amp;prog=ASTAT">https://secure.gradsch.psu.edu/gpms/index.cfm?searchType=fac&amp;prog=ASTAT</a> )

Graduate instruction and research opportunities are available in most areas of statistics and probability, including linear models, nonparametric statistics, robustness, statistical computing, analysis of count data, multivariate analysis, experimental design, reliability, stochastic processes and probability (applied and theoretical), distribution theory, statistical ecology, and biometrics.

Graduate students can gain practical experience in the application of statistical methodology through participation in the department's statistical consulting center and collaborative research activities. In addition, collaborative projects with other departments provide longer term experience and support for selected students. Most students gain valuable teaching experience by assisting in the teaching and grading of courses. In addition, Ph.D. students with proper qualifications can receive support for teaching undergraduate courses.

The Master of Applied Statistics (M.A.S.) program is a professional degree designed to provide training in statistics focused on developing data analysis skills, and exploration of all core areas of applied statistics, without going deeply into the mathematical statistics foundations. It aims to provide its graduates with broad knowledge in a wide range of statistical application areas.

The Doctor of Philosophy (Ph.D.) and Master of Science (M.S.) degrees in Statistics are designed for advanced studies in applied and theoretical statistics. Special emphases include biostatistics, statistical ecology, environmental statistics, genometrics, biometrics and statistical computation. The M.S. degree is appropriate preparation for the department's Ph.D. degree.

## Admission Requirements

Applicants apply for admission to the program via the Graduate School application for admission (<http://gradschool.psu.edu/prospective-students/how-to-apply>). Requirements listed here are in addition to Graduate Council policies listed under GCAC-300 Admissions Policies (<http://gradschool.psu.edu/graduate-education-policies>).

Scores from the Graduate Record Examinations (GRE), or from a comparable substitute examination accepted by the Statistics graduate program, are required for admission.

While applications from all students (including those who already have done graduate work) are reviewed, completion of a standard calculus sequence is regarded as a prerequisite. Students with a 3.00 or better junior/senior average (on a 4.00 scale) and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Students hoping to earn a Ph.D. in statistics may apply directly to the Ph.D. program without need for a master's degree.

## Degree Requirements

### Master of Applied Statistics (M.A.S.)

Requirements listed here are in addition to Graduate Council policies listed under GCAC-700 Professional Degree Policies (<http://gradschool.psu.edu/graduate-education-policies>).

For the M.A.S. degree, a minimum of 30 credits and a minimum grade-point average of 3.0 are required for graduation. Of the 30 credits, 24 must be courses from the Statistics department and 21 must be at the 500 level. The student must complete:

Code	Title	Credits
<b>Required Courses</b>		
<i>Applied Statistics</i>		
STAT 501	Regression Methods	3
STAT 502	Analysis of Variance and Design of Experiments	3
<i>Mathematical Statistics</i>		
STAT 414	Introduction to Probability Theory	3
STAT 415	Introduction to Mathematical Statistics	3
<i>Statistical Consulting</i>		
STAT 580	Statistical Consulting Practicum I	2
<b>Electives</b>		
To complete the remaining credit requirements, a student can select 9-15 9-15 credits from the following applied statistics courses:		
STAT 464	Applied Nonparametric Statistics	
STAT 480	Introduction to SAS	
STAT 500	Applied Statistics	
STAT 503	Design of Experiments	
STAT 504	Analysis of Discrete Data	
STAT 505	Applied Multivariate Statistical Analysis	
STAT 506	Sampling Theory and Methods	
STAT 507	Epidemiologic Research Methods	
STAT 509	Design and Analysis of Clinical Trials	
STAT 510	Applied Time Series Analysis	

In addition, students with suitable backgrounds may choose up to 6 credits from a departmental list of additional courses with approval from their adviser.

#### Culminating Experience

STAT 581	Statistical Consulting Practicum II (Capstone Project) <sup>1</sup>	1
Total Credits		30

<sup>1</sup> For all M.A.S. students, the STAT 581 course will have a comprehensive written project report required as part of the course, which serves as the culminating experience.

## Master of Science (M.S.)

Requirements listed here are in addition to Graduate Council policies listed under GCAC-600 Research Degree Policies. (<http://gradschool.psu.edu/graduate-education-policies>)

For the M.S. degrees, a student must complete at least 30 credits, including at least 27 at the 500 or 600 level; 21 of the 27 500-level credits must be formal course work from the Department of Statistics. A student must complete:

Code	Title	Credits
<b>Required Courses</b>		
<i>Applied Statistics</i>		
STAT 511	Regression Analysis and Modeling	3
STAT 512	Design and Analysis of Experiments	3
<i>Mathematical Statistics</i>		
STAT 513	Theory of Statistics I	3
STAT 514	Theory of Statistics II	3
<i>Stochastic Processes</i>		
STAT 515	Stochastic Processes and Monte Carlo Methods	3
<i>Statistical Consulting</i>		
STAT 580	Statistical Consulting Practicum I	2
STAT 581	Statistical Consulting Practicum II	1
<b>Electives</b>		
6 credits of electives		6
<b>Culminating Experience</b>		
STAT 600	Thesis Research	6
or STAT 610	Thesis Research Off Campus	
Total Credits		30

The student must also pass a written master's qualifying examination taken at the end of the first year. The thesis must be accepted by the advisers, a second reader, the head of the graduate program, and the Graduate School.

## Doctor of Philosophy (Ph.D.)

Requirements listed here are in addition to Graduate Council policies listed under GCAC-600 Research Degree Policies. (<http://gradschool.psu.edu/graduate-education-policies>)

The Department of Statistics requires a minimum total of 48 postbaccalaureate credits for the Ph.D. At least 42 credits, exclusive of the dissertation, must be in Statistics. Course work accepted for the M.S. in Statistics at Penn State will count toward the department's 48-credit requirement. In the case of students who have earned credits in an advanced degree program at another university or in another department

at Penn State, a maximum of 24 credits may count toward the 48-credit departmental requirement, subject to departmental approval.

For the Ph.D. degree, a student in Statistics must complete at least 48 credits, of which at least 42 must be STAT and at most three credits can be at the 400 level.

Code	Title	Credits
<b>Required Courses</b>		
<i>Core Course Requirements</i>		
STAT 511	Regression Analysis and Modeling	3
STAT 512	Design and Analysis of Experiments	3
STAT 513	Theory of Statistics I	3
STAT 514	Theory of Statistics II	3
STAT 515	Stochastic Processes and Monte Carlo Methods	3
STAT 553	Asymptotic Tools	3
<i>Additional Courses</i>		
STAT 517	Probability Theory	3
STAT 561	Statistical Inference I	3
STAT 580	Statistical Consulting Practicum I	2
STAT 581	Statistical Consulting Practicum II	1
STAT 590	Colloquium	2
STAT 592	Teaching Statistics	1
<b>Electives</b>		
Select 18 credits of the following:		18
STAT 518	Probability Theory	3
STAT 544	Categorical Data Analysis I	
STAT 552	Linear Models II	3
STAT 562	Statistical Inference II	
STAT 565	Multivariate Analysis	3
Other courses approved by the Graduate Studies Committee		
Total Credits		48

The student also must pass a written Ph.D. qualifying exam, typically at the end of the first year, and a comprehensive exam given at the end of the third year. There are two ways for students to complete their comprehensive examination. Typically, both written and oral components of the comprehensive involve the defense of a dissertation proposal evaluated by the Ph.D. committee. Alternatively, the student may have a written and oral comprehensive exam focusing on at least two key areas in Statistics. The examination focuses on the dissertation prospects and the student's preparation to undertake dissertation research, and is evaluated by the Ph.D. committee. A written and oral defense of a dissertation proposal would then occur at a later stage as per committee's recommendation. Students must have their dissertation proposal approved as specified in the Department of Statistics Graduate Student Handbook. The student then must submit an acceptable Ph.D. dissertation and pass a final oral examination (the dissertation defense). The dissertation must be accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School.

The Ph.D. in Statistics offers concentrations in Biometrics, Biostatistics, Environmental Statistics, and Genometrics. The course and the examination requirements remain the same under these concentrations, however, the student must take 15 credits of electives from a list of courses identified by the concentration.

## Doctoral Minor in Statistics

Requirements listed here are in addition to requirements for minors in Graduate Council policies listed under GCAC-600 Research Degree Policies (<http://gradschool.psu.edu/graduate-education-policies>) and GCAC-700 Professional Degree Policies (<http://gradschool.psu.edu/graduate-education-policies>).

The Department of Statistics has three possible paths for a Doctoral Minor in Statistics:

- Path 1: STAT 414/MATH 414 and STAT 415/MATH 415 and at least three 500-level courses from the department.
- Path 2: Five or more courses totaling 15 credits at the 500-level from the department. STAT 464 may also count toward the 15 credits.
- Path 3: Four 500-level courses totaling 12 credits from the department and one additional course of 3 credits approved by the department head or graduate studies chair.

Please note: STAT 500 will not be counted toward the Doctoral Minor in Statistics under any path.

For all paths, a 3.5 GPA is required in the courses to be counted toward the minor. Completion of one of the paths listed above, with the specified grade-point average, and the signature on the Graduate Minor Program form (<http://stat.psu.edu/education/graduate-minor-application/view>) constitutes approval of the Minor in Statistics. Official requests to add a minor to a doctoral student's academic record must be submitted to Graduate Enrollment Services prior to establishment of the Ph.D. committee and prior to scheduling the comprehensive examination. At least one Graduate Faculty member from the minor field must be on the student's Ph.D. committee.

## Dual-Titles

### Dual-Title M.S. and Ph.D. in Statistics and Operations Research

Requirements listed here are in addition to requirements listed in GCAC-208 Dual-Title Graduate Degree Programs (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-208-dual-title-graduate-degree-programs>).

The Operations Research dual-title degree program is administered by an Operations Research committee, which is responsible for management of the program. The program enables students from diverse graduate programs to attain and be identified with the tools, techniques, and methodology of operations research, while maintaining a close association with areas of application. Operations research is the analysis—usually involving mathematical treatment—of a process, problem, or operation to determine its purpose and effectiveness and to gain maximum efficiency. To pursue a dual-title degree under this program option the student must apply to the Graduate School and register through one of the approved graduate programs.

### Admission Requirements

Students must apply and be admitted to the graduate program in Statistics and the Graduate School before they can apply for admission to the dual-title degree program. Students must apply for enrollment into the dual-title Ph.D. in Operations Research (<https://bulletins.psu.edu/graduate/programs/majors/operations-research>) prior to taking their qualifying exam in Statistics. Students are encouraged to submit their application forms as early as possible, and not later than at least two semesters before their intended date of graduation. The "Request for

Dual-Title Degree in Operations Research" form must be filled out in consultation with the Graduate Coordinator in the Statistics Department and submitted to the Chair of the Operations Research Program.

For the M.S. dual-title degree in Operations Research (<https://bulletins.psu.edu/graduate/programs/majors/operations-research>), in addition to those prescribed by the graduate major program, prerequisites for acceptance to the program without deficiency include the following or their equivalent:

Code	Title	Credits
MATH 140	Calculus With Analytic Geometry I	4
MATH 141	Calculus with Analytic Geometry II	4
MATH 220	Matrices	2-3
CMPSC 101	Introduction to Programming	3
3 credits of probability and statistics		3

The "Request for Masters Dual-Title Degree in Operations Research" form must be filled out.

For the Ph.D. dual-title degree in Operations Research (<https://bulletins.psu.edu/graduate/programs/majors/operations-research>), in addition to those prescribed by the graduate major program, prerequisites for acceptance to the program without deficiency include the following or their equivalent:

Code	Title	Credits
MATH 401	Introduction to Analysis I	3
MATH 436	Linear Algebra	3
CMPSC 101	Introduction to Programming	3
3 credits of probability and statistics		3

The "Request for Ph.D. Dual-Title Degree in Operations Research" form must be filled out.

### Degree Requirements

To qualify for the dual-title degree, students must satisfy the requirements of the Ph.D. in Statistics. In addition, they must satisfy the requirements described below, as established by the Operations Research committee.

For the M.S. dual-title degree in Operations Research (<https://bulletins.psu.edu/graduate/programs/majors/operations-research>), the minimum requirements are:

- 6 credits in stochastic/statistical methods, including a minimum of 3 credits in each of the areas of statistical methods and stochastic processes;
- 6 credits in optimization, including a minimum of 3 credits in linear programming;
- 3 credits in computational methods; and
- 3 credits in applications/specialization.

A minimum of 9 credits must be in the 500 series. Particular courses may satisfy both the graduate major program requirements and those in the Operations Research program. The supervisor of the master's thesis must be a member of the Graduate Faculty recommended by the chair of the program granting the degree and approved by the Operations Research committee as qualified to supervise thesis work in operations research.

The minimum requirements for the Ph.D. dual-title degree in Operations Research (<https://bulletins.psu.edu/graduate/programs/majors/operations-research>) are:

- 9 credits in stochastic/statistical methods, including a minimum of 3 credits in each of the areas of statistical methods and stochastic processes;
- 9 credits in optimization, including a minimum of 3 credits in linear programming;
- 6 credits in computational methods, including a minimum of 3 credits in simulation; and
- 12 credits in applications/specialization.

A minimum of 18 credits must be in the 500 series, and particular courses may satisfy both the graduate major program requirements and those in the Operations Research (<https://bulletins.psu.edu/graduate/programs/majors/operations-research>) program.

### Qualifying Exam

The dual-title degree will be guided by the Qualifying Exam procedure of the Statistics graduate program. The qualifying exam for the dual-title degree may be given after at least 18 postbaccalaureate credits have been earned in graduate courses. Because students must first be admitted to a graduate major program of study before they may apply to and be considered for admission into a dual-title graduate degree program, dual-title graduate degree students may require an additional semester to fulfill requirements for both areas of study and, therefore, the qualifying examination may be delayed one semester beyond the normal period allowable. Operations Research must be integrated into the student's qualifying examination, and it may require additional examination beyond the one required by Statistics in order to assess whether the student should advance in both Statistics and Operations Research (<https://bulletins.psu.edu/graduate/programs/majors/operations-research>).

### Ph.D. Committee Composition

The Ph.D. committee must conform to all requirements of the primary program and the Graduate Council. In accordance with Graduate Council policy (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/gcac-602-phd-committee-formation>), the Ph.D. committee of a Statistics and Operations Research (<https://bulletins.psu.edu/graduate/programs/majors/operations-research>) dual-title doctoral degree student must include at least one member of the Operations Research Graduate Faculty. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role.

If the chair of the committee representing Statistics is not also a member of the Graduate Faculty in Operations Research (<https://bulletins.psu.edu/graduate/programs/majors/operations-research>), the member of the committee representing Operations Research must be appointed as co-chair.

### Comprehensive Exam

After completing all course work, doctoral students in the dual-title doctoral degree program in Statistics and Operations Research (<https://bulletins.psu.edu/graduate/programs/majors/operations-research>) must pass a comprehensive examination that includes written and oral components.

There are two ways for students to complete their comprehensive examination.

Typically, both written and oral components of the comprehensive examination involve the defense of a dissertation proposal, which must

contain core Statistics content and substantial Operations Research content, and is evaluated by the Ph.D. committee. The Operations Research representative(s) on the student's Ph.D. committee will participate in the evaluation of the comprehensive examination.

Alternatively, the student may have a written and oral comprehensive exam focusing on at least two key areas in Statistics with content from Operations Research (acting as a first minor field). The examination focuses on the dissertation prospects and the student's preparation to undertake dissertation research, and is evaluated by the Ph.D. committee. The Operations Research representative(s) on the student's Ph.D. committee will develop questions for and participate in the evaluation of the comprehensive examination. A written and oral defense of a dissertation proposal would then occur at a later stage as per committee's recommendation.

### Dissertation and Dissertation Defense

Upon completion of the doctoral dissertation, the candidate must pass a final oral examination (the dissertation defense) to earn the Ph.D. degree. Students enrolled in the dual-title program are required to write and orally defend a dissertation on a topic that reflects their original research and education in Statistics and Operations Research (<https://bulletins.psu.edu/graduate/programs/majors/operations-research>). The dissertation must be accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School.

## Dual-Title Ph.D. in Statistics and Social Data Analytics

Requirements listed here are in addition to requirements listed in GCAC-208 Dual-Title Graduate Degree Programs (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-208-dual-title-graduate-degree-programs>).

Statistics doctoral students seeking to attain and be identified with an interdisciplinary array of tools, techniques, and methodologies for social data analytics, while maintaining a close association with statistics, may apply to pursue a dual-title Ph.D. in Statistics and Social Data Analytics (<https://bulletins.psu.edu/graduate/programs/majors/social-data-analytics>). Social data analytics is the integration of social scientific, computational, informational, statistical, and visual analytic approaches to the analysis of large or complex data that arise from human interaction. The dual-title Ph.D. aims to enable scientists who expand the capability of social data analytics, and use those capabilities creatively to answer important social scientific questions and to address grand social challenges, in both academic and nonacademic settings.

### Admission Requirements

Students must apply and be admitted to the graduate program in Statistics and the Graduate School before they can apply for admission to the dual-title degree program. Applicants interested in the dual-title degree program may make their interest in the program known clearly on their applications to Statistics and include remarks in their statement of purpose that address the ways in which their research and professional goals in statistics reflect an expanded interest in Social Data Analytics-related research.

To apply to the dual-title Ph.D. in Statistics and Social Data Analytics (<https://bulletins.psu.edu/graduate/programs/majors/social-data-analytics>), a student must submit a letter of application and transcript, which will be reviewed by the Social Data Analytics Program. An applicant must have a minimum grade-point average of 3.0 (on a 4.0 point scale) to be considered for enrollment in the dual-title degree program. Students must apply for enrollment into the dual-title Ph.D. in Social Data Analytics

(<https://bulletins.psu.edu/graduate/programs/majors/social-data-analytics>) prior to taking the qualifying examination in Statistics.

### Degree Requirements

To qualify for the dual-title degree, students must satisfy the requirements of the Ph.D. in Statistics. In addition, they must satisfy the requirements described below, as established by the Social Data Analytics Committee. Within this framework, final course selection is determined by the student in consultation with academic advisers from their home department and Social Data Analytics.

### Course Work

The minimum course work requirements for the dual-title Ph.D. in Statistics and Social Data Analytics (<https://bulletins.psu.edu/graduate/programs/majors/social-data-analytics>) are as follows:

- Course work and other requirements for the Ph.D. in Statistics.
- SODA 501 (3 credits)
- SODA 502 (3 credits)
- 12 or more elective credits in Social Data Analytics from a list of courses maintained by the Social Data Analytics Committee. Collectively the elective credits must satisfy the following requirements:
  - (A) Core analytics distribution. 3 or more credits in courses focused on statistical learning, machine learning, data mining, or visual analytics. Courses approved as meeting this requirement are designated (A) on the list of approved electives.
  - (Q) Quantification distribution. 6 or more credits in courses focused on statistical inference or quantitative social science methodology. Courses approved as meeting this requirement are designated (Q) on the list of approved electives. (A Statistics Ph.D. student would typically satisfy this distribution requirement as a function of completing the requirements of the Statistics Ph.D.)
  - (C) Computational / informational distribution. 6 or more credits in courses focused on computation, collection, management, processing, or interaction with electronic data, especially at scale. Courses approved as meeting this requirement are designated (C) on the list of approved electives.
  - (S) Social distribution. 6 or more credits in courses with substantial content on the nature of human interaction and/or the analysis of data derived from human interaction and/or the social context or ethics or social consequences of social data analytics. Courses approved as meeting this requirement are designated (S) on the list of approved electives. (A Statistics Ph.D. student would typically satisfy this distribution requirement as a function of completing the requirements of the Statistics Ph.D.)
- Cross-departmental distribution.
  - 3 or more credits in approved courses with the prefix STAT or that of a primarily social science department. (A Statistics Ph.D. student would typically satisfy this distribution requirement as a function of completing the requirements of the Statistics Ph.D.)
  - 3 or more credits in approved courses with the prefix IST, GEOG, or that of a primarily computer science or engineering department.
  - 6 or more credits in approved courses outside Statistics.
  - 3 or fewer credits in approved courses at the 400-level.

Students are encouraged to take interdisciplinary courses that carry multiple (A), (Q), (C), (S) designations, as well as to select SODA electives

that also meet STAT requirements. In particular, the 12 elective SODA credits can be met with as few as 6 credits of appropriately chosen course work. Conversely, 6 credits of SODA course work, including SODA 501 and SODA 502, can be used to meet the STAT elective requirement. Within this framework, final course selection is determined by the student in consultation with academic advisers from Statistics and Social Data Analytics. (There are no formal maxima for the number of double-counted credits. For those meeting the SODA elective requirement with the minimum of 12 credits, the outside-program minimum effectively limits the number of primary degree STAT credits that count toward SODA at 6. For those meeting STAT elective requirements with the minimum of 18 credits, the 12 credit STAT minimum effectively limits the number of SODA credits that count toward STAT at 6.)

### Qualifying Exam

The dual-title degree will be guided by the qualifying exam procedure of the Statistics graduate program. The qualifying exam for the dual-title degree may be given after at least 18 postbaccalaureate credits have been earned in graduate courses. Because students must first be admitted to a graduate major program of study before they may apply to and be considered for admission into a dual-title graduate degree program, dual-title graduate degree students may require an additional semester to fulfill requirements for both areas of study and, therefore, the qualifying examination may be delayed one semester beyond the normal period allowable. There will be a single qualifying examination to assess whether the student should advance in both Statistics and Social Data Analytics (<https://bulletins.psu.edu/graduate/programs/majors/social-data-analytics>).

The Social Data Analytics Program maintains a list of recommended background and skills that it recommends students have in place by the time they begin the interdisciplinary course work required to complete the Social Data Analytics degree. The qualifying exam is the appropriate setting for assessing the student's preparation for the interdisciplinary work of the dual-title Ph.D. in Statistics and Social Data Analytics (<https://bulletins.psu.edu/graduate/programs/majors/social-data-analytics>).

### Ph.D. Committee Composition

The Ph.D. committee must conform to all requirements of the primary program and the Graduate Council. In accordance with Graduate Council policy (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/gcac-602-phd-committee-formation>), the Ph.D. committee of a Statistics and Social Data Analytics (<https://bulletins.psu.edu/graduate/programs/majors/social-data-analytics>) dual-title doctoral degree student must include at least one member of the Social Data Analytics Graduate Faculty. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role. If the chair of the committee representing Statistics is not also a member of the Graduate Faculty in Social Data Analytics, the member of the committee representing Social Data Analytics must be appointed as co-chair.

### Comprehensive Exam

After completing all course work, doctoral students in the dual-title doctoral degree program in Statistics and Social Data Analytics must pass a comprehensive examination that includes written and oral components.

There are two ways for students to complete their comprehensive examination.

Typically, both written and oral components of the comprehensive examination involve the defense of a dissertation proposal, which must

contain core Statistics content and substantial Social Data Analytics content, and is evaluated by the Ph.D. committee. The Social Data Analytics representative(s) on the student's Ph.D. committee will participate in the evaluation of the comprehensive examination.

Alternatively, the student may have a written and oral comprehensive exam focusing on at least two key areas in Statistics with content from Social Data Analytics (acting as a first minor field). The examination focuses on the dissertation prospects and the student's preparation to undertake dissertation research, and is evaluated by the Ph.D. committee. The Social Data Analytics representative(s) on the student's Ph.D. committee will develop questions for and participate in the evaluation of the comprehensive examination. A written and oral defense of a dissertation proposal would then occur at a later stage as per committee's recommendation.

### Dissertation and Dissertation Defense

Upon completion of the doctoral dissertation, the candidate must pass a final oral examination (the dissertation defense) to earn the Ph.D. degree. Students enrolled in the dual-title program are required to write and orally defend a dissertation on a topic that reflects their original research and education in Statistics and Social Data Analytics. The dissertation must be accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School.

## Integrated Undergrad-Grad Programs

### Integrated B.A. or B.S. in Mathematics and M.A.S. in Applied Statistics

Requirements listed here are in addition to requirements listed in GCAC-210 Integrated Undergraduate-Graduate (IUG) Degree Programs (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-210-integrated-undergraduate-graduate-degree-programs>).

The Integrated Undergraduate-Graduate (IUG) degree with B.A./B.S. in Mathematics and Master of Applied Statistics (M.A.S.) is designed to be completed in five years. This integrated degree will enable a select number of highly qualified and career-oriented students to obtain training in statistics focused on developing data analysis skills, and exploration of core areas of applied statistics at the graduate levels in addition to an undergraduate degree in Mathematics. The M.A.S. degree is a professional master's degree that emphasizes applications. The degree prepares students with interests in mathematics, computation, and the quantitative aspects of science for careers in industry and government as statistical analysts. Research divisions in the pharmaceutical industry, quality control, and quality engineering divisions in manufacturing companies, clinical research units, corporate planning and research units, and other data intensive positions require persons with training in mathematics, computation, database management, and statistical analysis, which this program will provide.

### Application Process

The number of openings in the integrated B.A./B.S. and M.A.S. program is limited. Students must apply to and meet the admission requirements of the Graduate School, as well as the graduate program in which they intend to receive their master's degree. Admission will be based on specific criteria and the recommendation of faculty. Students shall be admitted to an IUG program no earlier than the beginning of the third semester of undergraduate study at Penn State (regardless of transfer or AP credits accumulated prior to enrollment) and no later than the end of the second week of the semester preceding the semester of expected

conferral of the undergraduate degree, as specified in the proposed IUG plan of study. Applicants to the integrated program:

- Must be enrolled in the Mathematics B.A./B.S. program.
- Must have completed at least 60 credits of the undergraduate degree program including the two courses: STAT 414 and STAT 415.
- Must submit a transcript and a statement of purpose.
- Must present a departmental approved plan of study in the application process in consultation with the M.A.S. program director. The plan should cover the entire time period of the integrated program, and it should be reviewed periodically with an adviser as the student advances through the program.
- Must be recommended by the chair of Mathematics Department's undergraduate program committee. Two additional recommendation letters must be sent to the M.A.S. admissions committee.
- Must be accepted to the M.A.S. program in Statistics.

### Degree Requirements

Students in the IUG program must satisfy the requirements for both the B.A./B.S. and M.A.S. degrees; 120 credits are required for the B.A./B.S. and 30 credits for the M.A.S. The following twelve credits (number of credits in parentheses) can apply to both B.A./B.S. and M.A.S. degrees, six of these are at the 500 level:

Code	Title	Credits
<b>Courses Eligible to Double Count for Both Degrees</b>		
STAT 414	Introduction to Probability Theory	3
STAT 415	Introduction to Mathematical Statistics	3
STAT 501	Regression Methods	3
STAT 502	Analysis of Variance and Design of Experiments	3
Total Credits		12

If students accepted into the IUG program are unable to complete the M.A.S. degree, they are still eligible to receive their undergraduate degree if all the undergraduate degree requirements have been satisfied.

### Integrated B.S. in Statistics and M.A.S. in Applied Statistics

Requirements listed here are in addition to requirements listed in GCAC-210 Integrated Undergraduate-Graduate (IUG) Degree Programs (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-210-integrated-undergraduate-graduate-degree-programs>).

The Integrated Undergraduate-Graduate (IUG) degree with B.S. in Statistics and Master of Applied Statistics (M.A.S.) is designed to be completed in five years. This integrated degree will enable a select number of highly qualified and career-oriented students to obtain training in statistics focused on developing data analysis skills and exploration of core areas of applied statistics at the undergraduate and graduate levels. The M.A.S. degree is a professional master's degree that emphasizes applications and does not provide as much training in the mathematical and statistical theory. The degree prepares students with interests in mathematics, computation, and the quantitative aspects of science for careers in industry and government as statistical analysts. Research divisions in the pharmaceutical industry, quality control and quality engineering divisions in manufacturing companies, clinical research units, corporate planning and research units, and other data-intensive positions require persons with training in mathematics, computation, database management, and statistical analysis, which this program will provide.

## Application Process

The number of openings in the integrated B.S./M.A.S. program is limited. Students must apply to and meet the admission requirements of the Graduate School, as well as the graduate program in which they intend to receive their master's degree. Admission will be based on specific criteria and the recommendation of faculty. Students shall be admitted to an IUG program no earlier than the beginning of the third semester of undergraduate study at Penn State (regardless of transfer or AP credits accumulated prior to enrollment) and no later than the end of the second week of the semester preceding the semester of expected conferral of the undergraduate degree, as specified in the proposed IUG plan of study. Applicants to the integrated program:

- Must be enrolled in the Statistics B.S. program.
- Must have completed at least 60 credits of the undergraduate degree program, including the two courses: STAT 414 and STAT 415.
- Must submit a transcript and a statement of purpose.
- Must present a departmental approved plan of study in the application process in consultation with the M.A.S. program director. The plan should cover the entire time period of the integrated program, and it should be reviewed periodically with an adviser as the student advances through the program.
- Must be recommended by the chair of the department's undergraduate program committee.
- Must be accepted into the M.A.S. program in Statistics.

## Degree Requirements

Students in the IUG program must satisfy the requirements for both the B.S. and M.A.S. degrees; 120 credits are required for the B.S. and 30 credits for the M.A.S. The following twelve credits (number of credits in parentheses) can apply to both B.S. and M.A.S. degrees; six of these are at the 500 level:

Code	Title	Credits
<b>Courses Eligible to Double Count for Both Degrees</b>		
STAT 414	Introduction to Probability Theory	3
STAT 415	Introduction to Mathematical Statistics	3
STAT 501	Regression Methods	3
STAT 502	Analysis of Variance and Design of Experiments	3
Total Credits		12

If students accepted into the IUG program are unable to complete the M.A.S. degree, they are still eligible to receive their undergraduate degree if all the undergraduate degree requirements have been satisfied.

## Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the Tuition & Funding (<http://gradschool.psu.edu/graduate-funding>) section of The Graduate School's website. Students on graduate assistantships must adhere to the course load limits (<http://gradschool.psu.edu/graduate-education-policies/gsad/gsad-900/gsad-901-graduate-assistants>) set by The Graduate School.

GRE scores are required for consideration for assistantships.

World Campus students in graduate degree programs may be eligible for financial aid. Refer to the Tuition and Financial Aid section (<http://www.worldcampus.psu.edu/tuition-and-financial-aid>) of the World Campus website for more information.

## Courses

Graduate courses carry numbers from 500 to 699 and 800 to 899. Advanced undergraduate courses numbered between 400 and 499 may be used to meet some graduate degree requirements when taken by graduate students. Courses below the 400 level may not. A graduate student may register for or audit these courses in order to make up deficiencies or to fill in gaps in previous education but not to meet requirements for an advanced degree.

Statistics (STAT) Course List (<https://bulletins.psu.edu/university-course-descriptions/graduate/stat>)

## Learning Outcomes

### Master of Applied Statistics (M.A.S.)

1. Graduates shall demonstrate conceptual and practical knowledge of the broad aspects of Statistical analysis techniques. The core areas of Applied Statistics (Regression Analysis, Design of Experiment, Analysis of Variance, Analysis of Discrete Data, MANOVA, and many more) will be explored.
2. Graduates will be able to apply the statistical analysis techniques they learn to real problems. They will demonstrate proficiency in the working with others as a data analyst in a team setting, as well as in broad areas of data processing, data visualization, statistical analysis and interpretation of the statistical results. Students will also demonstrate adequate professional preparation for drawing sound conclusions and creating reports to aid in making decisions as data analysts and applied statisticians.
3. Graduates will demonstrate skills in communicating statistical findings and reports in a group setting and through oral presentations. They will be trained on development of recommendation reports, and discussion of consulting solutions.
4. Graduates will be able to demonstrate critical thinking skills when reviewing scientific papers, literature and numerical reports. They will be trained to have a firm grasp of statistical thinking and sound understanding of statistical conclusions.
5. Graduates will demonstrate knowledge of interpersonal working dynamics, ethical professional conduct and the ability to perform in a team environment. They will participate in professional networking, and engagement in professional activities and organizations serving the discipline and the industry.

### Master of Science (M.S.) and Doctor of Philosophy (Ph.D.)

1. Graduates shall demonstrate in-depth and advanced knowledge and understanding in statistics core areas of probability, statistical inference, modeling and computing. The core demonstration will include the application of these principles to problems in various contexts such as genetics, medicine, biology, environmental studies, and social and behavioral sciences, that are crucial for the practice of modern statistics.
2. Graduates shall demonstrate, at a level appropriate to a departmental colloquium, (i) knowledge of several outstanding problems or questions in diverse sub-fields of statistics, (ii) the experimental and theoretical origins of these problems, and (iii) the principle efforts proposed or underway to address them, including demonstrating critical thinking skills when reviewing scientific papers, literature and numerical reports.
3. Graduates shall demonstrate the ability to communicate professionally, in written and oral form, research work and

conclusions of statistical findings to statistical experts and non-expert audiences.

4. Graduates shall demonstrate (i) knowledge and understanding of professional standards of ethics and conduct, (ii) the ability to analyze situations to identify the standards that should apply including performing in a team environment, and (iii) describe how they may be appropriately acted upon. They will participate in professional networking, and engagement in professional activities and organizations serving the discipline and the broader scientific community and the industry.
5. Graduates shall have a specialty area within the broad domain of statistics, within which they shall demonstrate (i) advanced knowledge and understanding of the primary literature, (ii) the ability to analyze and judge new contributions to the primary literature, (iii) the ability to pose complex research problem(s) and identify the knowledge and methodologies required to address them, and (iv) the ability to apply that knowledge and those methodologies to create new knowledge and/or develop new theories and methods that advance (or show the potential to advance) knowledge and understanding within the specialty area, and to another discipline where their findings are applicable.

## Contact

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