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## Helpful University Park Offices and Phone Numbers

College of Engineering:	
Dean's Office, 101 Hammond Building	865-7537
Associate Dean Academic Programs, 101 Hammond Building	863-3750
Global Engineering Education, 205 Hammond Building	863-9899
Engineering Advising Center, 208 Hammond Building	863-1033
Assistant Dean for Student Services, 208G Hammond Building	865-7539
Multicultural Engineering Program, 208 Hammond Building	865-7138
Women in Engineering Program, 208 Hammond Building	863-1080
Engineering Career Resources and Employer Relations, 205 Hammond Building	863-1032
Outreach for Adult Learners, 128 Outreach Building	863-2504
Career Services, 101 MBNA Career Services Center	865-2377
Information Technology Services (ITS) Help Desk, 204 Wagner Building	865-4357
Counseling and Psychological Services (CAPS), 501 Student Health Center	863-0395
Student Disability Resources, 116 Boucke Building	863-1807
Penn State World Campus, 128 Outreach Building	865-5403
Division of Undergraduate Studies (DUS), 101 Grange Building	865-7576
Penn State Learning, 220 Boucke Building	865-1841
Office of Student Aid, 314 Shields Building	865-6301
Residence Life, 201 Johnston Commons	863-1710
Undergraduate Admissions (for transferring credits), 201 Shields Building	865-5471
Schreyer Honors College, 10 Schreyer Honors College (Atherton Hall)	863-2635
Office of Veterans Programs, 325 Boucke Building	863-0465
General Information, HUB Desk, First Floor Lobby	865-2000

## Sources of Information

This *Handbook* provides program information specifically for the undergraduate Computational Data Sciences major. It should be used as a supplement to the *College of Engineering Undergraduate Programs Guide* that is available online. The information in this *Handbook* pertains to students who entered or will be entering the major in Summer 2016, Fall 2016, or Spring 2017 semesters (2016 program year). Students entering the major in an earlier year should refer to the appropriate earlier version of the Handbook. Students in pre-major (ENGR) status may use this Handbook as a reference for scheduling; however, your official degree requirements will be established when you enter the major. For information about the computer science or computer engineering degrees, refer to the *Computer Science Undergraduate Handbook* and the *Computer Engineering Undergraduate Handbook*. All of these documents are available in the department office, 342G Information Sciences and Technology Building and online at <http://eecs.psu.edu/students/undergraduate/Majors-Minors-Certificates.aspx>. (If you are at a campus other than University Park, you should contact the College of Engineering representative at your location).

Although this *Handbook* lists all requirements for the Computational Data Sciences major, only those specific to this major are described in detail. Other general College and University requirements are discussed only briefly with references to more comprehensive supporting documents. Hard copies of these documents can be obtained from a Dean's office or local bookstore. Many are available on-line. A list of useful web resources is provided below. For easy reference, resource names are printed in bold throughout the *Handbook*.

<b>Registrar's Schedule of Courses</b> – <a href="https://public.lionpath.psu.edu/">https://public.lionpath.psu.edu/</a>
<b>Undergraduate Advising Handbook</b> – <a href="http://handbook.psu.edu">http://handbook.psu.edu</a>
<b>Academic Advising Portal</b> – <a href="http://advising.psu.edu">http://advising.psu.edu</a>
<b>School of EECS</b> – <a href="http://eecs.psu.edu">http://eecs.psu.edu</a>
<b>Penn State University</b> – <a href="http://www.psu.edu">http://www.psu.edu</a>
<b>Engineering Advising Center</b> – <a href="http://www.engr.psu.edu/Advising/">http://www.engr.psu.edu/Advising/</a>
<b>Bulletin of Baccalaureate Degree Programs</b> – <a href="http://bulletins.psu.edu/undergrad">http://bulletins.psu.edu/undergrad</a>
<b>University Faculty Senate Policies and Rules for Undergraduate Students</b> – <a href="http://www.senate.psu.edu/policies/">http://www.senate.psu.edu/policies/</a>
<b>Student Guide to General University Policies and Rules</b> – <a href="http://studentaffairs.psu.edu/conduct/docs/PoliciesRules.docx">http://studentaffairs.psu.edu/conduct/docs/PoliciesRules.docx</a>

<b>General Education and US &amp; International Cultures in the Curriculum</b> – <a href="http://bulletins.psu.edu/undergrad/generaleducation/">http://bulletins.psu.edu/undergrad/generaleducation/</a>
<b>LionPath</b> – <a href="http://launch.lionpath.psu.edu">http://launch.lionpath.psu.edu</a>
<b>Association of Women in Computing</b> - <a href="http://www.awc.cse.psu.edu">http://www.awc.cse.psu.edu</a>
<b>Association for Computing Machinery Student Chapter</b> – <a href="http://acm.psu.edu">http://acm.psu.edu</a>

For additional information, you can contact the **Engineering Advising Center** (208 Hammond, 863-1033), the Assistant Dean for Student Services (208 Hammond, 865-7539), or the **Department of Computer Science and Engineering** (342G Information Sciences and Technology Building, 865-9505). The structure in the Department of Computer Science and Engineering includes an Undergraduate Program Coordinator, an Undergraduate Adviser and an Undergraduate Staff Assistant, all of whom can provide information and guidance during your academic career. **If you communicate via e-mail, always use your Penn State account**, not another account such as g-mail.

### **The Data Sciences Major**

The Department of Computer Science and Engineering was created in 1993 with the merger of the Computer Engineering Program and the Computer Science Department. The department offers B.S. degrees in both computer science (CMPSC) and computer engineering (CMPEN) through the College of Engineering. It also offers the Computational Option of the inter-college Data Sciences B.S. degree.

The data sciences degree is part of an inter-college initiative between the College of Information Sciences and Technology (IST), College of Engineering, and Eberly College of Science to meet the need of professionals who can make sense of big data. The program provides students with the technical fundamentals of data science, with a focus on developing the knowledge and skills needed to manage and analyze large-scale, unstructured data to address an expanding range of problems in industry, government, and academia. As a result, data sciences graduates will possess the core skills and problem-solving approaches to compete for leading-edge analytics positions across many different industry sectors.

Computational Data Sciences, offered only through the Department of Computer Science and Engineering, focuses on the computational foundations of data science, including the design, implementation and analysis of software that manages the volume, heterogeneity and dynamic characteristics of large data sets and that leverages the computational power of multicore hardware. Students in this option will take upper-level courses in computer science and related fields to develop the skills necessary to construct efficient solutions to computational problems involving large data sets.

The mission of our undergraduate program is to prepare our students for a wide range of careers as computational data scientists and related positions in the field of computing. Our curriculum covers fundamental programming techniques and skills, broad knowledge of data science foundations, mathematical foundations of computing, and advanced topics in computing with large data sets. This curriculum provides students with the skills needed to design, develop, evaluate and analyze software solutions to computational problems involving large data and prepares them to be leaders throughout their

careers. This program is intended to produce data science professionals with a deep understanding of how to compute with large data and not merely technicians who can use off-the-shelf tools. Success requires a strong aptitude in mathematics.

Within a few years after graduation, graduates of the Computational Data Sciences major should be able to:

1. Apply appropriate theory, practices, and tools of data science to the specification, design, implementation, maintenance and evaluation of software that analyzes and manipulates large data sets.
2. Work and communicate effectively on multi-disciplinary teams.
3. Engage in continuous professional development through work assignments, graduate school study, professional training programs and independent learning.

During the first two years, students heading towards the Computational Data Sciences major take many courses in common with other engineering majors, including courses in mathematics. In addition, students take several specialized courses in the major, such as programming fundamentals. From these courses, students gain experience constructing software and completing individual and group projects. During the second two years, students complete a series of courses in computation theory, software systems and computing for data science. Students also select from numerous electives. Throughout the four years, students develop communication skills, including a senior year course in which students examine the complete design process and participate in a series of oral and written experiences similar to those that would be seen in industry.

**Because of the close relationships to Computational Data Sciences, concurrent majors in Computational Data Sciences and Computer Engineering or Computational Data Sciences and Computer Science are not permitted.**

### **Advising and Procedures for Major**

If you are a first- or second-year student at University Park who is intending to major in Computational Data Sciences, you can meet with an adviser at the **Engineering Advising Center (EAC)**, 208 Hammond Building, 863-1033. This office is open Monday through Friday, 8:00 a.m. to 5:00 p.m. (Walk-in advising is available but appointments are encouraged).

If you are a junior or senior who has been admitted into the Computational Data Sciences major you can meet with Dr. Mark Mahon, the Department of Computer Science and Engineering Undergraduate Adviser (342E IST, 867-5396). The email address, [advising@cse.psu.edu](mailto:advising@cse.psu.edu) will send email to him. Schreyer Scholars will be assigned a Scholar's Adviser. **If you communicate via e-mail, always use your Penn State account**, not another account such as Gmail.

Required courses for the Computational Data Sciences major and a suggested schedule are given on the following pages. Information about all majors at Penn State are listed in the **Bulletin of Baccalaureate Degree Programs**. The *Bulletin* is updated yearly and should be used along with this Handbook. Clarifications to the *Bulletin* are noted here.

The final responsibility for selecting courses and meeting degree requirements is yours. The role of your adviser is to suggest, recommend, and remind you of the requirements of the major and rules of the University. (Two helpful references for University procedures on-line are: **University Faculty Senate**

**Policies for Students** and the **Student Guide to General University Policies and Rules.**) When meeting with your adviser, always take a copy of your recent audits, transcript, your present schedule, and your plan for at least the next semester's courses.

Because data science is such a rapidly changing field, adjustments in course content and/or course offerings should be expected. It will be to your advantage to keep abreast of new course offerings, current course enhancements, and allowable course substitutions through regular contact with your adviser and the department office.

**Entrance to the Major (ETM)** – To qualify for the computer science major:

- (1) You must complete MATH 140, MATH 141, CMPSC 121, CMPSC 122, STAT 200, and IST 210 with a grade of C or better in each to be admitted to the Computational Data Sciences major. You may request admission to the major via LionPath as soon as you have completed 40 credits of **Penn State coursework** and before you complete 59 credits of Penn State coursework. **Note that, unlike other engineering majors, Computational Data Sciences requires CMPSC 121, CMPSC 122, STAT 200 and IST 210, but neither CHEM 110 nor MATH 250/251 for determining entrance to the major.**
- (2) You should complete at least two full semesters of coursework appropriate to the major and be in degree status. It is advisable to be taking MATH 220, MATH 230, and DS 220 during your second year in order to make normal progress. Be sure you're accumulating credits at a minimum rate of 30 credits per calendar year.

**Change of Major** – If you discover an interest in other areas of study or you are not admitted into the Computational Data Sciences, you should explore other possible majors and alternatives at the **Engineering Advising Center** or at online at the **Academic Advising Portal**.

**Concurrent Major** – Concurrent majors will not be allowed in Computational Data Sciences and Computer Engineering or Computational Data Sciences and Computer Science, although it is possible to obtain a concurrent major with another non-enrollment controlled program. (Also see page 3 “Enrollment Controls”).

**Registration** – When it is time to register for the next semester's courses, refer to this handbook and consult with your adviser to determine an appropriate set of courses. Then go to LionPath and use its Schedule Builder to construct your schedule. You should register as early as possible – **courses fill up quickly!**

Re-ordering your course schedule from the “sample schedule” will not necessarily delay graduation. The key to completing 123 credits over 4 years is to average approximately 15-16 credits per semester. Though many students do maintain this pace, it is not unusual for students to take lighter loads some semesters and to delay graduation. Needed credits may be taken during the summer (not necessarily at University Park). Some students may elect to register for a 9th semester to complete their degree requirements. Some electives are not offered every semester, so please be careful in your scheduling. This is especially true for co-op students.

**Prerequisite Courses** – If a CMPEN, CMPSC or DS course has a prerequisite course(s) specified you must complete the prerequisite course with an appropriate grade before taking the successor course. For most courses an appropriate grade is a grade of D or higher. **However, if the prerequisite course is a “C or higher” course, the appropriate grade is a C or higher.** Waiving of prerequisites is not normally approved and can only be done by the course instructor.

**Schedule Changes** – Schedule adjustments (course adds/drops) may be made online using LionPath during the first 5 calendar days of each semester. Detailed instructions, costs, and deadlines are provided in the university's *Undergraduate Advising Handbook*. After this time, you may still adjust your schedule, but any change is considered a late add or a late drop. REMEMBER: A student who has not yet been admitted to the major should seek advice at the Engineering Advising Center; a student who has been admitted should see the Department Undergraduate Adviser. Excessive dropping of courses may affect your eligibility for federal financial aid.

**General Education** – All Baccalaureate students at the University are required to complete 46 credits of General Education. A General Education course can be identified by its course suffix. You will partially meet these requirements by taking specific courses required for the computer science major, and by following the general guidelines below.

General Education consists of the following categories:

- first year seminar - at least 1 credit - courses with the designation PSU will fulfill this requirement, as will courses with the suffix S, T or X (see NOTE below).
- writing/speaking - 9 credits - course suffix of GWS
- quantification - 6 credits - suffix of GQ
- health and physical activity - 3 credits - suffix GHA
- natural sciences - 9 credits - suffix GN
- arts - 6 credits - suffix GA
- humanities - 6 credits - suffix GH
- social and behavioral sciences - 6 credits - suffix GS

Note: Some campuses do not have a first year seminar requirement, but instead require participation in a first year experience. If you started at such a campus you will need to take 1 additional credit of department list course work.

College of Engineering students will follow the University's General Education guidelines; refer to the College of Engineering *Undergraduate Programs Guide* and to the University's **Baccalaureate Degree Programs Bulletin** for a complete list of available courses. **Note that there are some restrictions in regards to the selection of the natural science elective (GN) – see page 12.**

**Writing Requirement** – All Penn State students have a Writing Across the Curriculum graduation requirement. You must complete at least 3 credits of writing-intensive courses selected from "W" courses offered within the major or college of enrollment. Student in the Computational Data Sciences major must complete DS 340W to satisfy the writing requirement.

**US & International Cultures Requirement** – Courses approved to fulfill this requirement will be designated as US, IL, or both US and IL. Students must complete 3 credits in United States Cultures (US) and 3 credits in International Cultures (IL). If a student takes a 3-credit course that is both US and IL, to complete the requirement, he/she must take another 3-credit course that is US, IL, or both US and IL. Education abroad courses and other credit-bearing experiences such as internships that meet this requirement will be designated as US, IL, or both US and IL. Most students complete this requirement by selecting GA, GS or GH courses which also satisfy the US/IL requirement.

**Graduation Requirements** – To graduate from the University, every student must:

- (1) Complete the course requirements for his or her major;

- (2) Earn at least a 2.0 cumulative grade-point average for all courses taken at the University; and
- (3) Earn at least a C in each of these courses: CMPSC 121, CMPSC 122, CMPSC 360, CMPSC 465, MATH 140, MATH 141, MATH 220, MATH 230, DS 220, DS 300, DS 340W, DS 410, DS 440, IST 210, STAT 200, STAT 380, STAT 414, STAT 415.

**Credit Acquisition** – In addition to taking courses at any Penn State campus, you may be able to earn credit through Independent Learning (World Campus) or by transferring credits from another school. Before taking a course at another university, check with the Admissions office and your adviser to be sure the course will transfer usefully. **Note that CMPSC 465, DS 340W and DS 440 must be taken at Penn State.**

**Cooperative Education Program** – The cooperative education program provides work experience by alternating periods of academic study and full-time employment in industry or government. The program typically starts at the beginning of the junior year and consists of three rotations, providing a cumulative work experience of one year.

If you have interest in the co-op program, you should obtain advising no later than your fourth semester from the designated co-op adviser, who will help you plan work and study schedules. You may earn up to 3 credits toward graduation in the Department List requirements.

If you prefer less of a time commitment, you can pursue one or more summer internships. You earn 1 credit per internship (maximum of 2 credits total) toward graduation in the Department List requirements.

If you are not a formal co-op or internship student, you may still take related summer jobs; however, you may not claim credits for jobs you arrange outside of the formal programs.

**Honors Program** – Students in the Schreyer Honors College (Atherton Hall, 863-2635) may earn honors in Computational Data Sciences by completing a thesis with a member of the CSE faculty. See an honors adviser if you are interested in finding out more. (The department office, 342G Information Sciences and Technology Building, can identify the honors advisers for you).

**Minors** – A minor is a specialization of at least 18 credits that supplements a major. Some courses may concurrently meet the requirements of our major. Popular minors for students in our department include:

- 1) Engineering Leadership Development
- 2) Engineering Entrepreneurship
- 3) Mathematics
- 4) Business/Liberal Arts

**Other Issues** – For additional information on minors, withdrawal, leaves of absence, concurrent majors, change of major, satisfactory/unsatisfactory credits, and other academic issues, refer to **University Faculty Senate Policies for Students**.

**Waivers and Exceptions** - All exceptions made in the degree requirements must be approved and documented using a College of Engineering petition form found and submitted online. Currently the form is available here:

<http://www.engr.psu.edu/e-petition/>

but note that this location/process is due to change.

Inquiries about exceptions and general degree requirements should be taken to the Department of Computer Science and Engineering Office (342G Information Sciences and Technology Building), to your adviser, or to the Engineering Advising Center. Note that petitions that require College level approval

(exceptions/waivers to College & University requirements) will NOT be accepted during the semester in which you plan to graduate.

**Academic Integrity** – Recognizing not only the value of integrity in the academic environment, but also its value for the practicing data scientist and for society at large, we in the department urge you to act as a responsible professional while you are a student. Academic integrity is defined as follows in Faculty Senate rule 49-20:

“Academic integrity is the pursuit of scholarly activity free from fraud and deception and is an educational objective of this institution. Academic dishonesty includes, but is not limited to, cheating, plagiarizing, fabricating of information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students.”

It is commonly accepted that people learn better if they can interact, discuss, and assist each other in solving problems and understanding concepts. Yet persons submitting identical homework papers overstep the bounds of beneficial interaction. The specific limits of acceptable collaboration will be spelled out by the instructor in each course in the course syllabus. The specifics may vary from course to course. Do not, for any reason, show another student sections of your code or write sections of code for another student. Do not put your code online in any location that might be publicly accessible. Any collaboration that exceeds these guidelines or the instructor’s guidelines will be considered cheating. Clearly, professionals share ideas but they should not use another’s work without clear acknowledgement of who did the work. Academic dishonesty in any form is not condoned or tolerated.

**Program Requirement Summary Chart** – On the next pages, you will find a semester-by-semester chart of what courses to take with notes describing any choices to be made or restrictions to be followed. Please realize that although all the courses listed are required for the degree, they need not be taken during the semesters shown in the charts. You should be sure to check course prerequisites before you deviate from the suggested schedule. **Care should be exercised to be sure core courses are taken in the proper sequence and in a time frame allowing you to meet entrance to major requirements.** Also remember that a course that is designated as **C required** must be completed with a C or higher in order to both move on to a course for which it is a prerequisite and to graduate. It is suggested that, if possible, you not wait until your last semester to take C required courses. A total of 123 credits is required for graduation.

## Sample Schedule of Courses by Semester

### SEMESTER 1

15 credits

MATH 140 GQ (Calculus I)\* 4  
 CMPSC 121 GQ (Programming Foundations I)\* 3  
 STAT 200 (Elementary Statistics)\* 4  
 GA, GH, GS or GN course 3  
 First Year Seminar 1

### SEMESTER 2

16 credits

MATH 141 GQ (Calculus II)\* 4  
 CMPSC 122 (Programming Foundations II)\* 3  
 IST 210 (Organization of Data)\* 3  
 ENGL 15 GWS (Rhetoric & Comp.) 3  
 GA, GH, GS or GN course 3

### SEMESTER 3

15 credits

DS 220 (Data Management for Data Sciences)\* 3  
 MATH 230 (Calculus III)\* 4  
 MATH 220 (Matrices) 2  
 CAS 100 A/B (Effective Speech) 3  
 GA, GH, GS or GN course 3

### SEMESTER 4

15 credits

STAT 380 (Data Science through Statistical Reasoning and Computation) 3  
 STAT 414 (Introduction to Probability Theory) 3  
 ENGL 202C GWS (Technical Writing) 3  
 GA, GH, GS or GN course 3  
 GA, GH, GS or GN course 3

### SEMESTER 5

16.5 credits

DS 300 (Data Privacy & Security)\* 3  
 CMPSC 360 (Discrete Math for CMPSC)\* 3  
 STAT 415 (Mathematical Statistics) 3  
 Course from Option LIST A below 3  
 GA, GH, GS or GN course 3

### SEMESTER 6

16.5 credits

CMPSC 465 (Data Structures & Algorithms)\* 3  
 CMPSC 448 (Machine Learning)\* 3  
 DS 340W (Applied Data Sciences) 3  
 Course from Option LIST B below 3  
 GA, GH, GS or GN course 3

(prerequisite: MATH 230)

Health & Physical Activity (GHA) 1.5 Health & Physical Activity (GHA) 1.5

**SEMESTER 7**

15 credits

**SEMESTER 8**

15 credits

CMPSC 442 (Artificial Intelligence)	3	DS 440 (Capstone)	3
CMPSC 461 (Programming Lang. Concepts)	3	DS 410 (Data Analytics at Scale)	3
Course from Option LIST A below	3	Course from Option LIST B below	3
GA, GH, GS or GN course	3	GA, GH, GS or GN course	3
Department List Course (General Elective)	3	Department List Course (General Elective)	3

\* A grade of C or better in these courses is required for graduation; (MATH 140, MATH 141, MATH 230, CMPSC 121, CMPSC 122, require a C or better for entrance to the major). If a course requires a "C" or better and the course is a prerequisite for another course, a "C" is required to meet the prerequisite.

Option List A

- CMPEN 454 Fundamentals of Computer Vision
- CMPSC 450 Concurrent Scientific Programming
- CMPSC 451 Numerical Computations
- CMPSC 455 Introduction to Numerical Analysis
- CMPSC 456 Introduction to Numerical Analysis II

Option List B

- CMPSC 431W Database Management Systems
- EE 456 Introduction to Neural Networks
- IST 441 Information Retrieval and Organization
- STAT 416 Stochastic Modeling
- STAT 440 Computational Statistics

## GRADUATION REQUIREMENTS NOTES

*Many of the courses below have prerequisites; some prerequisites are shown in parentheses; others are given in the Bulletin.*

### **I. Data Sciences/IST (18 credits):**

- IST 210 GQ (3) – Organization of Data
- DS 220 GQ (3) – Data Management for Data Sciences  
(prerequisite: IST 210)
- DS 300 GQ (3) – Data Privacy and Security  
(prerequisite: DS 220)
- DS 340W GQ (3) – Applied Data Sciences  
(prerequisite: DS 220)
- DS 410 GQ (3) – Data Analytics at Scale  
(prerequisite: DS 340W)
- DS 440 GQ (3) – Data Sciences Capstone  
(prerequisite: DS 340W)

### **II. Computer Science and Engineering (21 credits):**

- CMPSC 121 GQ (3) – Introduction to Programming Techniques  
(prerequisite: MATH 110 or MATH 140 concurrently or as a prerequisite)
- CMPSC 122 (3) – Intermediate Programming  
(prerequisite: CMPSC 121)
- CMPSC 360 (3) – Discrete Mathematics for Computer Science  
(Concurrent: CMPSC 122)
- CMPSC 442 (3) – Artificial Intelligence  
(Prerequisite: CMPSC 122; Concurrent: CMPSC 465)
- CMPSC 448 (3) – Machine Learning  
(Prerequisite: STAT 415, CMPSC 122)
- \*CMPSC 461 (3) – Programming Language Concepts  
(prerequisite: CMPSC 221; CMPSC 360)
- CMPSC 465 (3) – Data Structures and Algorithms

(prerequisite: CMPSC 360 or MATH 311W)

### **III. Statistics (12 credits):**

STAT 200 (3) – Elementary Statistics

(prerequisite: MATH 021)

STAT 380 (3) – Data Science through Statistical Reasoning and Computation

(prerequisite: STAT 200)

STAT 414 (3) – Introduction to Probability Theory

(prerequisite: MATH 230)

STAT 415 (3) – Introduction to Mathematical Statistics

(prerequisite: STAT 414)

### **IV. Technical Electives (12 credits):**

Select 6 credits from:

CMPEN 454 (3) – Fundamentals of Computer Vision

(prerequisite: MATH 230 or MATH 231; CMPSC 121 or CMPSC 201 )

CMPSC 450 (3) – Concurrent Scientific Programming

(prerequisite: CMPSC 121, CMPSC 201 or CMPSC 202; MATH 220; MATH 230 or MATH 231)

CMPSC 451 (3) – Numerical Computations

(prerequisite: 3 credits of programming; MATH 230 or MATH 231)

Note: Students may take only one course for credit from CMPSC 451 and 455.

CMPSC 455 (3) – Introduction to Numerical Analysis I

(prerequisite: MATH 220; MATH 230 or MATH 231; and 3 credits of programming)

Note: Student may take only one course for credit from CMPSC 451 and 455.

CMPSC 456 (3) – Introduction to Numerical Analysis II

(prerequisite: CMPSC 455)

Select 6 credits from:

CMPSC 431W (3) – Database Management Systems

(prerequisite: CMPSC 221; ENGL 202C)

EE 456 (3) – Introduction to Neural Networks

(prerequisite: CMPSC 201 or CMPSC 202; MATH 220)

IST 441 (3) - Information Retrieval and Organization

(prerequisite: IST 210, IST 240)

STAT 416 (3) - Stochastic Modeling

(prerequisite: STAT 318 or STAT 414; MATH 230)

STAT 440 (3) - Computational Statistics

(prerequisite: STAT 200, STAT 415, MATH 220 )

**Some courses are NOT offered every semester or even every year.**

### **III. Communications (9 credits):**

ENGL 15 GWS (3) – Rhetoric and Composition (ENGL 30 GWS may be substituted)

ENGL 202C GWS (3) – Technical Writing

CAS 100 A/B (3) – Effective Speech

### **IV. Quantification (14 credits):**

Mathematics (14 credits):

MATH 140 GQ (4) – Calculus with Analytic Geometry I

MATH 141 GQ (4) – Calculus with Analytic Geometry II

MATH 220 GQ (2) – Matrices

MATH 230 (4) – Calculus and Vector Analysis (combination of MATH 231 (2) and MATH 232 (2) may be substituted)

## V. Health Sciences and Physical Education (3 credits):

The Health Science/Physical Activity (ESACT) requirement can be met by taking one 3-credit course or various credit combinations, most frequently two 1.5 credit courses, (which can be taken in different semesters). A student who completes an ROTC program may use 3 credits of ROTC to satisfy the GHA requirement.

## VI. Natural Sciences (9 credits):

Nine credits of Natural Science (GN) are required. Any GN courses except the following may be used:

ASTRO 1, 10, 11, 120, 140; all BI SC courses; All below CHEM 110 (except 3 credits of CHEM 106 can be used); PHYS 250, 251, all below PHYS 211, GEOSC 20

## VII. Arts, Humanities, Social and Behavioral Sciences, US/IL (18 credits):

Six credits are required in each of the 3 categories: Arts (A), Humanities (H), and Social and Behavioral Sciences (S), as listed under the University's General Education Guidelines [see the University's **Baccalaureate Degree Programs Bulletin**]. You may use your Arts, Humanities, or Social or Behavioral Sciences selections to fulfill the University's US & International Cultures requirement.

*\*For US/IL courses, see **General Education and US & International Cultures in the Curriculum** online and the *Semester Course Schedules*. The College of Engineering encourages you to be a Globally Ready student in which *Global Readiness is defined as having the knowledge and appreciation of the global nature of engineering and related professions, as well as the challenges and opportunities associated with contemporary worldwide issues. Students should graduate, being ready to practice their profession in a global context by being sensitive to and respectful of the differences that affect professional practice throughout the world.* To assist you in being Globally Ready the College of Engineering encourages you to select as an IL course one of the courses off the list which may be found at:*

<http://www.engr.psu.edu/global/students/illimited.htm>.

## X. Department List (General Elective) Guidelines (6 credits)

**Choose enough credits to bring the total number of credits up to at least 123.** If your US/IL course was not an Arts, Humanities, Social or Behavioral Sciences course, it may be counted in this list. (For US/IL courses, see the *General Education and US & International Cultures in the Curriculum* booklet). These are sometimes called approved free electives or general electives, but the following restrictions apply:

- no courses not satisfying minimum requirements for baccalaureate degree program (see course descriptions in *University Bulletin*)
- no courses described as intended for non-science or non-technical majors in course descriptions in *University Bulletin* (**You may take non-technical courses**, but look at the *Bulletin* to be sure the description doesn't say "for non-science majors only").
- no courses similar or remedial to a required course or course already taken (when in doubt, check with your advisor before scheduling the course). For example, you may not include 2 credits of MATH 140A or 2 credits of CHEM 106.
- not ENGL 4, 5, or any other remedial English
- none of the following:
  - Astronomy (ASTRO) 1, 10, 11, 120, 140
  - Biological Science (BI SC) 1, 2, 3, 4
  - Chemistry (CHEM) 1, 3, 108, 101
  - Computer Science (CMPSC) 100, 203
  - Earth and Mineral Sciences (EM SC) 150
  - English as a Second Language (ESL) 004
  - Language and Literacy Education (LL ED) 5, 10
  - Mathematics (MATH) 200, MATH below 140
  - Philosophy (PHIL) 12
  - Physical Science (PH SC) 7
  - Physics (PHYS) 250, 251, PHYS below 211
  - Science, Technology, and Society (S T S) 150
  - Speech Communication (CAS) 126, 283
  - Statistics (STAT or MATH) below 318, 401
  - STAT (MATH) 318, STAT (MATH) 319, STAT (MATH) 414, STAT (MATH) 415, STAT (MATH) 418, MATH 444, 445
- no more than 3 credits of ROTC
- no more than 6 credits of music performance courses
- no more than 3 additional credits of physical education
- no more than 3 credits of Cooperative Education
- no more than 2 credits of Engineering Internship
- no more than 3 credits of CHEM 106

- None of the following IST courses: IST 140, 220, 230, 240, 242, 261, 311, 361

**XI. First Year Seminar (1 credit):**

Small interactive classes that allow first-year students to meet faculty and alumni, explore different majors and career opportunities, or focus on hands-on projects and skill development. If you started at a campus that did not require First Year Seminar or are a transfer credit then you must add an additional credit to the Department List requirement.