Cognitive Science

**Website:** [http://cogsci.cas.lehigh.edu/](http://cogsci.cas2.lehigh.edu/)

The mission of the Cognitive Science Program is to advance the study of minds and brains, real or artificial, in all their aspects, through research and teaching. This interdisciplinary field, encompassing the fields of psychology, linguistics, computer science, philosophy, anthropology, and neuroscience, provides excellent preparation for life in the age of information. The program aims to instill in students a solid grasp of the intellectual problems, frameworks, and methodologies currently available; to provide experience exploring these through guided research; and to foster the desire to create and disseminate new knowledge. With this foundation, students are well prepared for a wide variety of careers at the interfaces of technology, minds, brains, and behavior, and for graduate study in Cognitive Science or any of the contributing disciplines.

We offer undergraduate B.A. and B.S. degrees in Cognitive Science, an undergraduate minor, and a graduate certificate. A Cognitive Science major is easy to combine with a second major in the humanities, natural sciences, social sciences, or computer science.

**B.A. IN COGNITIVE SCIENCE**

The B.A. in Cognitive Science requires a minimum of 14 courses. All majors take COGS 007, an introduction to cognitive science, plus core courses in cognitive psychology, philosophy, artificial intelligence, and cognitive neuroscience, and collaterals in computer science.

They also complete a course in research methods or tools. Students then pursue their individual interests by completing at least five electives from across three tracks. A capstone integration occurs in one required two-semester senior project (COGS 301 and COGS 302, or, for Honors, COGS 391 and COGS 392), in which students focus on a topic of their choice spanning at least two cognitive science sub-disciplines.

Additional coursework in affiliated disciplines is recommended, to be selected in consultation with the major adviser and dependent upon anticipated career path. These courses may fulfill college distribution requirements. Note: A number of major courses have pre-requisites. Students considering this major should check pre-requisites and plan accordingly. A preliminary meeting with the program director may be useful.

**Collateral Requirements**

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>COGS 007</td>
<td>Introduction to Cognitive Science</td>
</tr>
<tr>
<td>CSE 007</td>
<td>Introduction to Programming</td>
</tr>
<tr>
<td>CSE 003</td>
<td>Introduction to Programming, Part A</td>
</tr>
<tr>
<td>CSE 004</td>
<td>Introduction to Programming, Part B</td>
</tr>
<tr>
<td>PSYC 001</td>
<td>Introduction to Psychology</td>
</tr>
<tr>
<td>ECO 001</td>
<td>Principles of Economics</td>
</tr>
<tr>
<td>ANTH 011</td>
<td>Cultural Diversity and Human Nature</td>
</tr>
<tr>
<td>BIOS 130</td>
<td>Biostatistics</td>
</tr>
</tbody>
</table>

**Introductory Course**

- COGS 007: Introduction to Cognitive Science

**Disciplinary Core Courses**

- COGS/PSYC 117: Cognitive Psychology
- COGS/CSE 127: Survey of Artificial Intelligence
- COGS/PSYC 176: Cognitive Neuroscience
- COGS/PHIL 250: Philosophy of Mind
- COGS/PHIL 251: Philosophical Foundations of Cognitive Science

**Major Electives**

- Select a minimum of five electives, with at least one course from each of the three tracks.

**Senior Project**

- 6-8 credits

**Total Credits for B.A.:** 40-47

**B.S. IN COGNITIVE SCIENCE**

The B.S.in Cognitive Science entails additional courses beyond those in the B.A. to provide both additional breadth and depth. It requires a minimum of 20 courses. All majors take COGS 007, an introduction to cognitive science, plus core courses in cognitive psychology, philosophy, artificial intelligence, and cognitive neuroscience, and collaterals in computer science, math, and social science. They also complete two courses in research methods or tools and at least one semester of supervised research.

Students then pursue their individual interests by choosing a concentration area from among three tracks and completing at least six electives with a minimum of four in the concentration area. A capstone integration occurs in the required two-semester senior project (COGS 301 and COGS 302, or, for Honors, COGS 391 and COGS 392), in which students focus on a topic of their choice spanning at least two cognitive science sub-disciplines.

Additional coursework in affiliated disciplines is recommended, to be selected in consultation with the major adviser and dependent upon anticipated career path. These courses may fulfill college distribution requirements. Note: A number of major courses have pre-requisites. Students considering this major should check pre-requisites and plan accordingly. A preliminary meeting with the program director may be useful.

**Collateral Requirements**

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>MATH 021</td>
<td>Calculus I</td>
</tr>
<tr>
<td>or MATH 051</td>
<td>Survey of Calculus I</td>
</tr>
<tr>
<td>or MATH 075</td>
<td>Calculus I, Part A</td>
</tr>
<tr>
<td>&amp; MATH 076</td>
<td>and Calculus I, Part B</td>
</tr>
<tr>
<td>CSE 007</td>
<td>Introduction to Programming</td>
</tr>
<tr>
<td>or CSE 003</td>
<td>Introduction to Programming, Part A</td>
</tr>
<tr>
<td>&amp; CSE 004</td>
<td>Introduction to Programming, Part B</td>
</tr>
<tr>
<td>CSE 140</td>
<td>Foundations of Discrete Structures and Algorithms</td>
</tr>
<tr>
<td>or CSE 160</td>
<td>Introduction to Data Science</td>
</tr>
<tr>
<td>PSYC 001</td>
<td>Introduction to Psychology</td>
</tr>
<tr>
<td>or ECO 001</td>
<td>Principles of Economics</td>
</tr>
<tr>
<td>or ANTH 011</td>
<td>Cultural Diversity and Human Nature</td>
</tr>
</tbody>
</table>

**Total Credits for B.S.:** 40-47

For Artificial Intelligence and Formal Models Concentration:

- COGS 140: Foundations of Discrete Structures and Algorithms
- MATH 231: Calculus II, Part A
- MATH 232: Calculus II, Part B
- or MATH 231: Calculus II, Part B

For all other concentrations:

- PSYC 201 & PSYC 202: Research Methods and Data Analysis I & II

**Introductory Course**

- 4 credits

**Disciplinary Core Course**

- 16 credits

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**Senior Project in Cognitive Science:**

Proposal and Senior Project in Cognitive Science: Execution

Credits may be split between two advisers but must total 3 per semester.

**Honors Thesis in Cognitive Science:**

Proposal and Honors Thesis in Cognitive Science: Project Execution and Thesis

Credits may be split between two advisers but must total 4 per semester.
COGS/PSYC 117  Cognitive Psychology
COGS/CSE 127 or COGS/CSE 327  Survey of Artificial Intelligence
COGS/PSYC 176  Cognitive Neuroscience
COGS/PHIL 250 or COGS/PHIL 251  Philosophy of Mind
COGS 183 or COGS 184  Cognitive Neuroscience Recitation

Concentrations  18-24
Choose six electives from the concentration lists, at least four of them from within the same concentration. The lists are the same for the B.A. and the B.S. Requirements specific to each concentration for the B.S. are as follows:

Artificial Intelligence and Formal Models
CSE 017  Programming and Data Structures
Cognitive Neuroscience
COGS 140  Introduction to Linguistics

Cognition, Culture, and Meaning
COGS 140  Introduction to Linguistics

Research Experience  2-4
COGS 161  Supervised Research

Senior Project  6-8
COGS 301 & COGS 302  Senior Project in Cognitive Science: Proposal and Senior Project in Cognitive Science: Execution
Or

Total Credits  46-56

Collateral courses may count toward CAS distribution requirements where applicable.

BIOS 044 pre-reqs: any CHM course that fulfills the pre-requisite for BIOS 041, plus BIOS 041 Introduction to Cellular and Molecular Biology and BIOS 042 Introduction to Cellular and Molecular Biology Laboratory. These are not part of the major but can count toward CAS Natural Science distribution.

Students are encouraged to take the required research credits beginning in the second year or even earlier. At least two semesters of relevant research experience (minimum 4 credits) are required for B.S. students prior to enrolling in COGS 391 Honors Thesis in Cognitive Science: Proposal and COGS 392 Honors Thesis in Cognitive Science: Project Execution and Thesis for their senior project.

May be repeated for credit.

Credits may be split between two advisers but must total 3 per semester (301,302) or 4 per semester (391, 392).

Not available in the Artificial Intelligence concentration.

This option is not available in the Artificial Intelligence concentration.

MAJOR ELECTIVES

Artificial Intelligence and Formal Models
CSE 017  Programming and Data Structures
CSE 042  Game Design
CSE 140  Foundations of Discrete Structures and Algorithms
CSE 262  Programming Languages
CSE 318  Introduction to the Theory of Computation
CSE 326  Fundamentals of Machine Learning
CSE 331  User Interface Systems and Techniques
CSE 335  Topics on Intelligent Decision Support Systems
CSE 337  Reinforcement Learning
CSE 347  Data Mining
CSE 348  AI Game Programming
CSE 360  Introduction to Mobile Robotics
CSE 428  Semantic Web Topics
CSE 431  Intelligent Agents
PHIL/MATH 014  Symbolic Logic
PHIL/MATH 114  Metalogic
PHIL/MATH 214  Topics in Philosophical Logic
PHIL 265  Philosophy of Mathematics

Cognition, Culture, and Meaning
COGS/ANTH/MLL 140  Introduction to Linguistics
CSE 252  Computers, the Internet, and Society
EDUC 391  Educational Linguistics
JOUR 135  Human Communication
PHIL 128  Philosophy Of Science
PHIL 135  Modern Philosophy
PHIL 139  Contemporary Philosophy
PHIL 220  Epistemology
PHIL 228  Philosophy of Specific Sciences
PHIL 260  Philosophy of Language
PSYC 307  Higher Order Cognition
PSYC 313  Person Perception
PSYC 314  Social Cognition
PSYC/HMS 344  Health Care Reasoning and Decision Making
PSYC 351  Children’s Thinking
PSYC/EVST 357  Psychology of Environmental Issues
PSYC 362  Cognition in Practice & Policy
PSYC/GS 365  Human Development in Cross-Cultural Perspective
PSYC 376  Child Language and Social Inequality
PSYC 384  Self and Identity
SOC 118  Sociology of Culture
SOC 336  Computational Text Analysis

Cognitive Neuroscience
ANTH 012  Intro to Archaeology and Human Origins
BIOS 044  Introduction to Integrative and Comparative Biology
ANTH 145  Human Evolution
BIOS 276  Central Nervous System and Behavior
BIOS 277  Experimental Neuroscience Laboratory
BIOS 332  Behavioral Neuroanatomy
BIOS 365  Neurobiology of Sensory Systems
BIOS 366  Diseases of the Nervous System
Candidates, at least three of the four courses must be outside the major program, and require at least two of these to be at the 400-level, and the four courses must be spread over at least two departments. For Lehigh degree candidates, at least three of the four courses must be outside the major department. The certificate will entail 12-16 credits.

The Graduate Certificate requires four courses from the list below.

**MINOR IN COGNITIVE SCIENCE**
The undergraduate minor in Cognitive Science requires five courses:

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>COGS 007</td>
<td>Introduction to Cognitive Science</td>
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</tbody>
</table>

Four additional courses selected from among the major's core courses and major electives, with at least two of these being Disciplinary Core Courses.

**Total Credits:** 16-20

**PROGRAM HONORS**
Majors seeking to graduate with honors in cognitive science must have a 3.30 GPA in the major, a 3.30 GPA overall, and complete a high quality senior thesis with enrollment in COGS 391 Honors Thesis in Cognitive Science: Proposal and COGS 392 Honors Thesis in Cognitive Science: Project Execution and Thesis. Theses submitted for honors will be evaluated by a committee of at least three cognitive science faculty.

**GRADUATE CERTIFICATE IN COGNITIVE SCIENCE**
The graduate certificate provides the opportunity to develop an interdisciplinary perspective on human and machine intelligence. It is available to both enrolled and external students.

Students in Lehigh University graduate degree programs such as computer science, psychology, and instructional technology are encouraged to participate with the approval of an adviser in their major program. Non-degree, post-baccalaureate individuals with sufficient background to complete the coursework are also welcome to undertake the certificate. The certificate may be especially relevant to those working in technology-related fields. Interested individuals should contact the Director of the Cognitive Science Program. External candidates will also need to apply to the College of Arts and Sciences for non-degree graduate status.

The certificate will appear on the student's transcript after submission of a signed completion form by the program director.

The Graduate Certificate requires four courses from the list below. At least two of the courses must be at the 400-level, and the four courses must be spread over at least two departments. For Lehigh degree candidates, at least three of the four courses must be outside the home department. The certificate will entail 12-16 credits.

**ELECTIVES**

**Computer Science**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>CSE 327</td>
<td>Artificial Intelligence Theory and Practice</td>
</tr>
<tr>
<td>CSE 331</td>
<td>User Interface Systems and Techniques</td>
</tr>
<tr>
<td>CSE 335</td>
<td>Topics on Intelligent Decision Support Systems</td>
</tr>
<tr>
<td>CSE 348</td>
<td>AI Game Programming</td>
</tr>
<tr>
<td>CSE 409</td>
<td>Theory of Computation</td>
</tr>
<tr>
<td>CSE 426</td>
<td>Fundamentals of Machine Learning</td>
</tr>
<tr>
<td>CSE 428</td>
<td>Semantic Web Topics</td>
</tr>
<tr>
<td>CSE 431</td>
<td>Intelligent Agents</td>
</tr>
<tr>
<td>CSE 435</td>
<td>Topics on Intelligent Decision Support Systems</td>
</tr>
<tr>
<td>CSE 437</td>
<td>Reinforcement Learning and Markov Decision Processes</td>
</tr>
<tr>
<td>CSE 447</td>
<td>Data Mining</td>
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<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>CSE 002</td>
<td>Mobile Robotics</td>
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**Psychology**

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<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>PSYC 001</td>
<td>Survey of Artificial Intelligence</td>
</tr>
<tr>
<td>PSYC 098</td>
<td>Machine Learning and Decision Making</td>
</tr>
<tr>
<td>PSYC 127</td>
<td>Artificial Intelligence</td>
</tr>
<tr>
<td>PSYC 128</td>
<td>Advanced Topics in Cognitive Science</td>
</tr>
<tr>
<td>PSYC 250</td>
<td>Seminar in Cognitive Neuroscience</td>
</tr>
<tr>
<td>PSYC 307</td>
<td>Higher Order Cognition</td>
</tr>
<tr>
<td>PSYC 313</td>
<td>Person Perception</td>
</tr>
<tr>
<td>PSYC 314</td>
<td>Social Cognition</td>
</tr>
<tr>
<td>PSYC 316</td>
<td>The Talking World: Psychology and Neuroscience of Speaking</td>
</tr>
<tr>
<td>PSYC 320</td>
<td>Health Care Reasoning and Decision Making</td>
</tr>
<tr>
<td>PSYC 347</td>
<td>Cognitive Neuroscience of Memory</td>
</tr>
<tr>
<td>PSYC 351</td>
<td>Children’s Thinking</td>
</tr>
<tr>
<td>PSYC 355</td>
<td>Seminar in Cognitive Neuroscience</td>
</tr>
<tr>
<td>PSYC 358</td>
<td>Social Cognition</td>
</tr>
<tr>
<td>PSYC 377</td>
<td>Attention and Attentional Failures</td>
</tr>
<tr>
<td>PSYC 402</td>
<td>Developmental Psychology</td>
</tr>
<tr>
<td>PSYC 403</td>
<td>Cognitive Psychology</td>
</tr>
<tr>
<td>PSYC 406</td>
<td>Social Cognition</td>
</tr>
<tr>
<td>PSYC 433</td>
<td>Cognitive Psychology</td>
</tr>
<tr>
<td>PSYC 448</td>
<td>Seminar in Psychology of Language</td>
</tr>
<tr>
<td>PSYC 464</td>
<td>Seminar in Cognition</td>
</tr>
<tr>
<td>PSYC/COGS 478</td>
<td>Ontological Psychology</td>
</tr>
<tr>
<td>PSYC 480</td>
<td>Seminar in Cognitive Development</td>
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</tbody>
</table>

**Philosophy**

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<thead>
<tr>
<th>Course</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>PHIL/COGS 250</td>
<td>Philosophy of Mind</td>
</tr>
<tr>
<td>PHIL 260</td>
<td>Philosophy of Language</td>
</tr>
</tbody>
</table>

**Sociology and Anthropology**

<table>
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<tr>
<th>Course</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>BIOS 392</td>
<td>Honors Thesis in Cognitive Science</td>
</tr>
</tbody>
</table>

**Total Credits:** 16-20

Note: These particular 200-level courses may be taken by graduate students.

**Courses**

**COGS 007 Introduction to Cognitive Science 4 Credits**
What is a mind? How is the mind related to the brain? Could we make an artificial mind? Issues concerning knowledge representation and intelligence in minds and computers as investigated by psychologists, philosophers, linguists, neuroscientists, and researchers in artificial intelligence.

**COGS 091 Special Topics 1-4 Credits**
Intensive study of a topic of special interest not covered in other courses.

**Repeat Status:** Course may be repeated.

**Attribute/Distribution:** HU, SS

**COGS 098 1-4 Credits**
Repeat Status: Course may be repeated.

**COGS 117 (PSYC 117) Cognitive Psychology 4 Credits**
The architecture and dynamics of the human mind: How we acquire knowledge through perception, represent and activate it in memory, and use it to communicate, make decisions, solve problems, and reason creatively. May not be taken pass/fail.

**Prerequisites:** PSYC 001 or COGS 007

**Attribute/Distribution:** SS

**COGS 127 (CSE 127) Survey of Artificial Intelligence 3 Credits**
An introduction to artificial intelligence (AI) intended for non-majors. AI concepts, systems, and history. Credit will not be given for both CSE/COGS 127 and CSE/COGS 327.

**Prerequisites:** CSE 002 or CSE 004 or CSE 007
COGS 140 (ANTH 140, MLL 140) Introduction to Linguistics 4 Credits
Relationship between language and mind; formal properties of language; language and society; how languages change over time. May not be taken pass/fail.
Attribute/Distribution: SS

COGS 161 Supervised Research 1-3 Credits
Research under the direct supervision of a faculty member in the cognitive science program. Students must arrange the particular project with a faculty member before enrolling. Consent of program director required.
Repeat Status: Course may be repeated.
Attribute/Distribution: ND

COGS 176 (PSYC 176) Cognitive Neuroscience 4 Credits
Perception and cognitive neuroscience as the link between mental processes and their biological bases. Visual and auditory perception; the control of action; neuropsychological syndromes of perception, language, memory, and thought; neural network (connectionist) models of mental processes. May not be taken pass/fail.
Prerequisites: PSYC 001 or COGS 007
Attribute/Distribution: ND

COGS 183 (PSYC 183) Cognitive Psychology Recitation 1 Credit
Research, discussion, and analysis of topics in cognitive psychology.
Prerequisites: PSYC 117 or COGS 117
Can be taken Concurrently: PSYC 117, COGS 117

COGS 184 (PSYC 184) Cognitive Neuroscience Recitation 1 Credit
Research, discussion, and analysis of topics in cognitive neuroscience.
Prerequisites: PSYC 176 or COGS 176
Can be taken Concurrently: PSYC 176, COGS 176

COGS 191 Special Topics 1-4 Credits
Intensive study of a topic of special interest not covered in other courses.
Repeat Status: Course may be repeated.
Attribute/Distribution: HU, SS

COGS 250 (PHIL 250) Philosophy of Mind 4 Credits
An exploration of the mind-body problem. Are the body and mind distinct substances (dualism); or is there only body (materialism); or only mind (idealism)? Other views to be considered include behaviorism (the view that behavior can be explained without recourse to mental states), and the view that the mind is a complex computer. Student must have completed at least one Philosophy course at the 100-level.
Attribute/Distribution: HU

COGS 251 (PHIL 251) Philosophical Foundations of Cognitive Science 4 Credits
Cognitive Science is the study of aspects of natural and artificial minds: perception, cognition, reasoning, action, and language. Several fields intersect here: artificial intelligence, linguistics, cognitive psychology, philosophy, and neuroscience. Central issues include: the nature of representation, the boundaries of cognitive science, and consciousness. We will survey the foundational philosophical aspects of these issues within Cognitive Science. Student must have completed at least one Philosophy course at the 100-level, or major in Cognitive Science.
Attribute/Distribution: HU

COGS 291 Special Topics 1-4 Credits
Intensive study of a topic of special interest not covered in other courses.
Repeat Status: Course may be repeated.
Attribute/Distribution: HU, SS

COGS 300 Apprentice Teaching 1-4 Credits

COGS 301 Senior Project in Cognitive Science: Proposal 1-3 Credits
For students not intending to apply for program Honors. Background reading and preparation of a short written proposal are conducted in the first semester in consultation with a faculty adviser. Students must enroll for a total of three credits which may be split between the sections of a primary and secondary adviser. Consent of program director and project adviser required.

COGS 302 Senior Project in Cognitive Science: Execution 1-3 Credits
For students not intending to apply for program Honors. Execution of the project is conducted in the second semester in consultation with a faculty adviser. A presentation will be given at the end of the semester. Students must enroll for a total of three credits which may be split between the sections of a primary and secondary adviser. Consent of program director and project adviser required.
Repeat Status: Course may be repeated.
Prerequisites: COGS 301

COGS 327 (CSE 327) Artificial Intelligence Theory and Practice 3 Credits
Detailed analysis of a broad range of artificial intelligence (AI) algorithms and systems. Problem solving, knowledge representation, reasoning, planning, uncertainty and machine learning. Applications of AI to areas such as natural language processing, vision, and robotics. Credit will not be given for both CSE/COGS 127 and CSE/COGS 327.
Prerequisites: CSE 017 and CSE 140

COGS 361 Independent Research 2-4 Credits
Independent research in cognitive science with a faculty advisor. Students must arrange the particular project with a faculty advisor before enrolling. Consent of program director required.
Repeat Status: Course may be repeated.
Attribute/Distribution: ND

COGS 391 Honors Thesis in Cognitive Science: Proposal 1-4 Credits
For students not intending to apply for program Honors. Background reading and preparation of a written proposal are conducted in the first semester in consultation with a faculty adviser. An oral presentation will be given at end of the semester. Students must enroll for four credits which may be split between co-advisers. Consent of program director and project adviser required.
Repeat Status: Course may be repeated.

COGS 392 Honors Thesis in Cognitive Science: Project Execution and Thesis 1-4 Credits
For students with 3.3 or higher major and overall GPA by the spring of the junior year, who want to undertake a project with the potential for program Honors. Literature review and preparation of a written proposal are conducted in the first semester in consultation with a faculty adviser. An oral presentation will be given at end of the semester. Students must enroll for four credits which may be split between co-advisers. Consent of program director and project adviser required.
Repeat Status: Course may be repeated.
Prerequisites: COGS 391

COGS 394 Special Topics in Cognitive Science 3-4 Credits
Topics vary from semester to semester. Topics are presented at an advanced level.

COGS 405 Individual Study in Cognitive Science 1-6 Credits
Study of a topic not covered in regular course offerings. By arrangement with a consulting faculty member. Consent of program director required.
Repeat Status: Course may be repeated.
COGS 423 (PSYC 423) Foundations of Cognitive Science 3 Credits
Survey of fundamental theory and methodologies from artificial intelligence, linguistics, cognitive psychology, philosophy, and neuroscience, as well as salient research problems such as knowledge acquisition and representation, natural language processing, skill acquisition, perception and action, and the philosophical question of intentionality.

COGS 478 (PSYC 478) Ontological Psychology 3 Credits
Principles and constraints for modeling psychological phenomena. Representation; perception; memory; knowing; learning; emotions; consciousness; language; rationality.