CHEMISTRY, BACHELOR OF SCIENCE (B.S.) WITH A CONCENTRATION IN CHEMICAL SCIENCE

The curriculum in chemistry prepares students for graduate study in chemistry and related fields and for admission to schools of medicine, dentistry, pharmacy and veterinary medicine. It prepares students to teach in secondary schools or to work in chemical and industrial laboratories and in related fields of business and industry. The department also offers required and elective courses in chemistry to students in other programs of study.

The Department of Chemistry offers five areas of concentration for completing the Bachelor of Science in Chemistry: chemical science, professional chemist, professional chemist with honors, biochemistry and chemical modeling. With proper selection of electives, the degree satisfies admission requirements to most schools of medicine, dentistry, pharmacy and veterinary medicine.

The chemical science concentration is tailored for the pre-professional study of the health sciences and other interdisciplinary areas where an emphasis on chemistry is sought. This concentration for the bachelor’s degree in chemistry permits students to select more courses from other disciplines. With fewer requirements in mathematics, physics and chemistry, this concentration is one option for students planning to study medicine or dentistry.

Student learning outcomes

Upon completing this program, students will know how to do the following:

Chemistry core outcomes

• Demonstrate proficiency in the major concepts and theoretical principles of chemistry, critical thinking and problem-solving skills
• Demonstrate proficiency in laboratory skills, including wet chemistry and instrumental methods, and laboratory safety practices
• Demonstrate communication skills, both written and oral, needed to explain chemical phenomenon
• Demonstrate proficiency in scientific literacy skills including searching and reading scientific publications
• Demonstrate proficiency in laboratory skills, including wet chemistry and instrumental methods, and laboratory safety practices
• Demonstrate an understanding of the need for ethical practices in chemistry

Chemical science concentration-specific outcomes

• Demonstrate the ability to apply basic laboratory skills to more advanced laboratory work, including data collection, data analysis and report writing

Special requirements

Students must complete 36-37 credits in chemistry and 33-35 credits of ancillary requirements in addition to general education requirements.

A minimum grade of C is required in each prerequisite course except for CHEM 100, which requires a minimum grade of B.

Course | Title | Hours
--- | --- | ---
CHEM 100 | Introductory Chemistry (if required through placement qualifiers) | 3
CHEM 101 | General Chemistry I | 3
CHEM 102 | General Chemistry II | 3
CHEM 301 | Organic Chemistry | 3
CHEM 302 | Organic Chemistry | 3
CHEM 309 | Quantitative Analysis | 3
CHEM 313 | Physical Chemistry I | 3-4
or CHEM 314 | Physical Chemistry I with Math Modules | 1
CHEZ 101 | General Chemistry Laboratory I | 1
CHEZ 102 | General Chemistry Laboratory II | 1
CHEZ 301 | Organic Chemistry Laboratory I | 2
CHEZ 302 | Organic Chemistry Laboratory II | 2
CHEZ 309 | Quantitative Analysis Laboratory | 2

VCU students in other programs who wish to declare chemistry as their major must complete CHEM 101, CHEZ 101, CHEM 102 and CHEZ 102, each with a minimum grade of C and have a minimum GPA in their chemistry courses of 2.0.

Degree requirements Chemistry, Bachelor of Science (B.S.) with a concentration in chemical science

Course | Title | Hours
--- | --- | ---
Select 30 credits of general education courses in consultation with an adviser. | 30

Major requirements

• Major core requirements

CHEM 102 | General Chemistry II | 4
& CHEZ 102 | General Chemistry Laboratory II | 4
CHEM 301 | Organic Chemistry | 5
& CHEZ 301 | Organic Chemistry Laboratory I | 5
CHEM 302 | Organic Chemistry | 5
& CHEZ 302 | Organic Chemistry Laboratory II | 5
CHEM 309 | Quantitative Analysis | 5
& CHEZ 309 | Quantitative Analysis Laboratory | 5
CHEZ 313 | Physical Chemistry Laboratory I | 2
or CHEM 314 | Physical Chemistry I with Math Modules | 2

CHEM 315 | Physical Chemistry II | 3
CHEM 320 | Inorganic Chemistry I | 3
CHEM 398 | Professional Practices and Perspectives Seminar | 1
CHEM 499 | Chemistry Capstone Experience | 0

• Additional major requirements

Capstone requirements

Select at least one two-credit 400-level CHEZ course or two credits of CHEM 392 or CHEM 492 and at least one three-credit 400- or 500-level CHEM course from the electives listed below.

Ancillary requirements
Chemistry, Bachelor of Science (B.S.) with a concentration in chemical science

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 101 &amp; CHEZ 101</td>
<td>General Chemistry I and General Chemistry Laboratory I (both satisfy general education BOK for natural sciences and AOI for scientific and logical reasoning)</td>
<td>4</td>
</tr>
<tr>
<td>HUMS 202</td>
<td>Choices in a Consumer Society</td>
<td>1</td>
</tr>
<tr>
<td>MATH 200</td>
<td>Calculus with Analytic Geometry I (satisfies general education quantitative foundations)</td>
<td>4</td>
</tr>
<tr>
<td>MATH 201</td>
<td>Calculus with Analytic Geometry II</td>
<td>4</td>
</tr>
<tr>
<td>STAT 210 or STAT 212</td>
<td>Basic Practice of Statistics or Concepts of Statistics</td>
<td>3</td>
</tr>
<tr>
<td>Physics sequence (select one sequence)</td>
<td>General Physics I and General Physics II (PHYS 201 satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)</td>
<td>8-10</td>
</tr>
<tr>
<td>PHYS 201 &amp; PHYS 202</td>
<td>University Physics I and University Physics II (PHYS 207 satisfies general education BOK for natural sciences and AOI for scientific and logical reasoning)</td>
<td></td>
</tr>
<tr>
<td>Experiential fine arts</td>
<td>1-3</td>
<td></td>
</tr>
<tr>
<td>Foreign language through the 102 level (by course or placement)</td>
<td>0-6</td>
<td></td>
</tr>
<tr>
<td>Open electives</td>
<td>Select any course.</td>
<td>30-41</td>
</tr>
<tr>
<td>Total Hours</td>
<td></td>
<td>120</td>
</tr>
</tbody>
</table>

Students in this concentration meet the capstone requirement by taking at least one two-credit 400-level CHEZ course or two credits of CHEM 392 (http://bulletin.vcu.edu/search/?P=CHEM%20392) or CHEM 492 (http://bulletin.vcu.edu/search/?P=CHEM%20492) and at least one three-credit 400- or 500-level CHEM course from the electives list.

What follows is a sample plan that meets the prescribed requirements within a four-year course of study at VCU. Please contact your adviser before beginning course work toward a degree.

**Freshman year**

**Fall semester**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 101 &amp; CHEZ 101</td>
<td>General Chemistry I and General Chemistry Laboratory I (both satisfy general education BOK for natural sciences and AOI for scientific and logical reasoning)</td>
<td>4</td>
</tr>
<tr>
<td>MATH 200</td>
<td>Calculus with Analytic Geometry I (satisfies general education quantitative foundations)</td>
<td>4</td>
</tr>
<tr>
<td>UNIV 111</td>
<td>Play course video for Focused Inquiry I</td>
<td>3</td>
</tr>
</tbody>
</table>

**Spring semester**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 301</td>
<td>Organic Chemistry</td>
<td>5</td>
</tr>
<tr>
<td>CHEM 301 &amp; CHEZ 301</td>
<td>Organic Chemistry Laboratory I</td>
<td></td>
</tr>
<tr>
<td>CHEM 309</td>
<td>Quantitative Analysis</td>
<td>5</td>
</tr>
<tr>
<td>CHEM 309 &amp; CHEZ 309</td>
<td>Quantitative Analysis Laboratory</td>
<td></td>
</tr>
</tbody>
</table>
Students in this concentration meet the capstone requirement by taking at least one two-credit 400-level CHEZ course or two credits of CHEM 392 (http://bulletin.vcu.edu/search/?P=CHEM%20392) or CHEM 492 (http://bulletin.vcu.edu/search/?P=CHEM%20492) and at least one three-credit 400- or 500-level CHEM course from the electives list.

The minimum number of credit hours required for this degree is 120.

### Accelerated B.S. and M.S.

The accelerated B.S. and M.S. program allows qualified students to earn both the B.S. and M.S. in Chemistry in a minimum of five years by completing approved graduate courses during the senior year of their undergraduate program. Students in the program may count nine hours of graduate courses toward both the B.S. and M.S. degrees. Thus, the two degrees may be earned with a minimum of 141 credits rather than the 150 credits necessary if the two degrees are pursued separately.

Students holding these degrees will have had advanced training in chemistry through a combination of laboratory and classroom work and gained important professional development skills. Students may have the ability to design and incorporate graduate courses in another discipline as part of the accelerated program based on their career objectives. The goal of the accelerated program is to significantly enhance the student’s qualifications to pursue a career in industry, teaching or the government. Alternatively, students who distinguish themselves may be able to pursue advanced study at the doctoral level in chemistry or chemical biology on an accelerated timetable.

### Entrance to the accelerated program

Interested undergraduate students should consult with their adviser as early as possible to receive specific information about the accelerated program, determine academic eligibility and submit (no later than two semesters prior to graduating with a baccalaureate degree, that is, before the end of the spring semester of their junior year) an Accelerated Program Declaration Form to be approved by the graduate program director. Limited spaces may be available in the accelerated program. Academically qualified students may not receive approval if capacity has been reached.

Minimum qualifications for entrance to this accelerated program include completion of 90 undergraduate credit hours including CHEM 313 or CHEM 314, CHEZ 313, CHEM 315, CHEM 320, CHEM 302 and CHEM 314, CHEM 392 and CHEM 309 and CHEZ 309; a minimum overall GPA of 3.0; and a minimum GPA of 3.25 in chemistry course work. Students who are interested in the accelerated program should consult with the graduate faculty advisor to the chemistry master’s program before they have completed 60 credits. Successful applicants would enter the program in the fall semester of their senior year.

Once enrolled in the accelerated program, students must meet the standards of performance applicable to graduate students as described in the "Satisfactory academic progress (http://bulletin.vcu.edu/academic-regs/grad/satisfactory-academic-progress/)" section of the Graduate Bulletin, including maintaining a 3.0 GPA. Guidance to students admitted to the accelerated program is provided by both the undergraduate chemistry adviser and the faculty adviser to the chemistry graduate program.

### Admission to the graduate program

Entrance to the accelerated program enables the student to take the approved shared courses that will apply to the undergraduate and graduate degrees. However, entry into an accelerated program via an
approved Accelerated Program Declaration Form does not constitute application or admission into the graduate program. Admission to the graduate program requires a separate step that occurs through a formal application. In order to continue pursuing the master’s degree after the baccalaureate degree is conferred, accelerated students must follow the admission to graduate study requirements outlined in the VCU Bulletin. Three reference letters (at least one from a chemistry faculty member) must accompany the application.

**Degree requirements**

The Bachelor of Science in Chemistry with a concentration in chemical science degree will be awarded upon completion of a minimum of 120 credits and the satisfactory completion of all undergraduate degree requirements as stated in the Undergraduate Bulletin. Students in the accelerated program will be required to take CHEM 409 and CHEZ 409 during the fall semester of senior year, as well as three credits of CHEM 392 or CHEM 492 each semester of the senior year in lieu of some elective course work.

A maximum of nine graduate credits may be taken prior to completion of the baccalaureate degree. These graduate credits will substitute as open elective credits for the undergraduate degree. These courses are shared credits with the graduate program, meaning that they will be applied to both undergraduate and graduate degree requirements.

Undergraduate students admitted to the accelerated program may select nine credits from the four approved courses below.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 504</td>
<td>Advanced Organic Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 510</td>
<td>Atomic and Molecular Structure</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 511</td>
<td>Chemical Thermodynamics and Kinetics</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 520</td>
<td>Advanced Inorganic Chemistry</td>
<td>3</td>
</tr>
</tbody>
</table>

**Recommended course sequence/plan of study**

What follows is the recommended plan of study for students in the chemical science concentration in the accelerated program beginning in the fall of the junior year prior to admission to the accelerated program in the senior year.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall semester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHEM 313</td>
<td>Physical Chemistry I</td>
<td>3-4</td>
</tr>
<tr>
<td>or CHEM 314</td>
<td>Physical Chemistry I with Math Modules</td>
<td></td>
</tr>
<tr>
<td>CHEZ 313</td>
<td>Physical Chemistry Laboratory I (if taken)</td>
<td>2</td>
</tr>
<tr>
<td>General education course</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>General education courses or open electives</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Term Hours:</td>
<td>14-15</td>
<td></td>
</tr>
<tr>
<td>Spring semester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHEM 315</td>
<td>Physical Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>Foreign language (101 level)</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Open electives</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Term Hours:</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Senior year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall semester</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Accelerated B.S. and M.S.**

The accelerated B.S. and M.S. program allows academically talented students to earn both the B.S. in Chemistry with a concentration in chemical science and the M.S. in Forensic Science with a concentration in forensic chemistry/drugs and toxicology in a minimum of five and a half years by completing approved graduate courses during the senior year of their undergraduate program. Students in the program may count up to 12 hours of graduate courses toward both the B.S. and M.S. degrees. Thus, the two degrees may be earned with a minimum of 150 credits rather than the 162 credits necessary if the two degrees are pursued separately.

Students holding these degrees will have both foundational work in chemistry and advanced training in forensic science through a combination of laboratory and classroom work and will have gained important professional development skills. The goal of the accelerated program is to significantly enhance the student’s qualifications to pursue a career in the forensic science field. Alternatively, students who distinguish themselves may be able to pursue advanced study in doctoral or professional studies on an accelerated timetable.

**Entrance to the accelerated program**

Interested undergraduate students should consult with their adviser as early as possible to receive specific information about the accelerated program, determine academic eligibility and submit an Accelerated
Program Declaration Form to be approved by the graduate program director. Limited spaces may be available in the accelerated program. Academically qualified students may not receive approval if capacity has been reached.

Minimum qualifications for entrance to this accelerated program include completion of 90 undergraduate credit hours including CHEM 301 and CHEM 302 with laboratories (CHEZ 301 and CHEZ 302), CHEM 309 and laboratory (CHEZ 309); an overall GPA of 3.3; and a GPA of 3.0 in chemistry course work. Two reference letters (at least one from a chemistry or forensic science faculty member) must accompany the Accelerated Program Declaration Form.

Once enrolled in the accelerated program, students complete the course work for the B.S. in Chemistry with a concentration in chemical science with the exception of adding CHEM 409 and CHEZ 409, which are needed as prerequisites for several graduate forensic science courses and can fulfill open elective credits. Students must meet the standards of performance applicable to graduate students as described in the “Satisfactory academic progress (http://bulletin.vcu.edu/academic-regs/grad/satisfactory-academic-progress/)” section of Bulletin, including maintaining a 3.0 GPA. Guidance to students in an accelerated program is provided by both the undergraduate chemistry adviser and the forensic science graduate program director.

Admission to the graduate program

Entrance to the accelerated program enables the student to take the approved shared courses that will apply to the undergraduate and graduate degree requirements. However, entry into an accelerated program via an approved Accelerated Program Declaration Form does not constitute application or admission into the graduate program. Admission to the graduate program requires a separate step that occurs through a formal application. In order to continue pursuing the master’s degree after the baccalaureate degree is conferred, accelerated students must follow the admission to graduate study requirements outlined in the VCU Bulletin.

Degree requirements

The Bachelor of Science in Chemistry degree will be awarded upon completion of a minimum of 120 credits and the satisfactory completion of all undergraduate degree requirements as stated in the Undergraduate Bulletin.

A maximum of 12 graduate credits may be taken prior to completion of the baccalaureate degree. These graduate credits substitute for required major electives and open electives for the undergraduate degree. These courses are shared credits with the graduate program, meaning that they will be applied to both undergraduate and graduate degree requirements.

The graduate forensic science courses that may be taken as an undergraduate, once a student is admitted to the program, are:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRSC 581</td>
<td>Forensic Analysis of Fire Debris and Explosive Evidence</td>
<td>3</td>
</tr>
<tr>
<td>FRSC 582</td>
<td>Forensic Analysis of Paint and Fiber Evidence</td>
<td>3</td>
</tr>
<tr>
<td>FRSC 644</td>
<td>Analytical Considerations in Forensic Toxicology</td>
<td>3</td>
</tr>
<tr>
<td>FRSC 671</td>
<td>Instrumentation in Forensic Chemistry</td>
<td>2</td>
</tr>
<tr>
<td>FRSC 672</td>
<td>Advanced Drug Analysis</td>
<td>3</td>
</tr>
<tr>
<td>FRSZ 671</td>
<td>Instrumentation in Forensic Chemistry Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>STAT 543</td>
<td>Statistical Methods I</td>
<td>3</td>
</tr>
</tbody>
</table>

Recommended course sequence/plan of study

What follows is the recommended plan of study for students interested in the accelerated program beginning in the fall of the junior year prior to admission to the accelerated program in the senior year.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 313</td>
<td>Physical Chemistry I</td>
<td>3-4</td>
</tr>
<tr>
<td>or CHEM 314</td>
<td>Physical Chemistry I with Math Modules</td>
<td></td>
</tr>
<tr>
<td>CHEZ 313</td>
<td>Physical Chemistry Laboratory I</td>
<td>2</td>
</tr>
<tr>
<td>Foreign language 101</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>General education course</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Open elective</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Term Hours:</td>
<td>14-15</td>
<td></td>
</tr>
<tr>
<td>Spring semester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHEM 315</td>
<td>Physical Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 409</td>
<td>Instrumental Analysis</td>
<td>5</td>
</tr>
<tr>
<td>&amp; CHEZ 409</td>
<td>and Instrumental Analysis Laboratory</td>
<td></td>
</tr>
<tr>
<td>Foreign language 102</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Open electives</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Term Hours:</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

Senior year

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 499</td>
<td>Chemistry Capstone Experience</td>
<td>0</td>
</tr>
<tr>
<td>FRSC 671 &amp; FRSZ 671</td>
<td>Instrumentation in Forensic Chemistry and Instrumentation in Forensic Chemistry Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>STAT 543</td>
<td>Statistical Methods I</td>
<td>3</td>
</tr>
<tr>
<td>Open electives</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Term Hours:</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Spring semester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FRSC 644</td>
<td>Analytical Considerations in Forensic Toxicology</td>
<td>3</td>
</tr>
<tr>
<td>FRSC 672</td>
<td>Advanced Drug Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Experiential fine arts</td>
<td>1-3</td>
<td></td>
</tr>
<tr>
<td>Open electives</td>
<td>8</td>
<td></td>
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<tr>
<td>Term Hours:</td>
<td>15-17</td>
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Fifth year

<table>
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<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRSC 570</td>
<td>Forensic Science Seminar</td>
<td>1</td>
</tr>
<tr>
<td>FRSC 660 or FRSC 661</td>
<td>Toolmark Examinations or Analysis of Pattern Evidence</td>
<td>3</td>
</tr>
<tr>
<td>or FRSC 662</td>
<td>Forensic Identification</td>
<td></td>
</tr>
<tr>
<td>FRSC 670</td>
<td>Forensic Evidence and Criminal Procedure</td>
<td>3</td>
</tr>
<tr>
<td>FRSC 673 &amp; FRSZ 673</td>
<td>Forensic Microscopy and Forensic Microscopy Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>Term Hours:</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Spring semester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>Credits</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>FRSC 565</td>
<td>Scientific Crime Scene Investigation</td>
<td>3</td>
</tr>
<tr>
<td>FRSC 570</td>
<td>Forensic Science Seminar</td>
<td>1</td>
</tr>
<tr>
<td>FRSC 645</td>
<td>Applications in Forensic Toxicology</td>
<td>3</td>
</tr>
<tr>
<td>FRSC 677</td>
<td>Professional Practices and Expert Testimony</td>
<td>3</td>
</tr>
<tr>
<td>FRSC 793</td>
<td>Directed Research in Forensic Science</td>
<td>1</td>
</tr>
</tbody>
</table>

**Term Hours:** 11

**Sixth year**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>FRSC 570</td>
<td>Forensic Science Seminar</td>
<td>1</td>
</tr>
<tr>
<td>FRSC 675</td>
<td>Forensic Serology and DNA Analysis</td>
<td>2</td>
</tr>
<tr>
<td>FRSC 793</td>
<td>Directed Research in Forensic Science</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Concentration elective</td>
<td>4</td>
</tr>
</tbody>
</table>

**Term Hours:** 9