Guide to Courses Recommended for ScM Candidates
2014 - 2015

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Please contact the appropriate graduate representative for questions on courses related to your concentration. For general questions regarding the SoE academic programs, please contact the director of graduate studies Prof. Sherief Reda (sherief_reda@brown.edu).
Biomedical Engineering (BME)
ScM Program Director: Prof. Jacquelyn Schell (Jacquelyn_Schell@Brown.edu)

The Sc.M. degree has a course as well as thesis requirement. Students must complete 8 upper level 1000/2000 courses, up to 3 of which can be graduate independent study, i.e. BIOL 2980/ENGN 1980. At least 2 of the courses must be 1000/2000 level courses in engineering and at least 2 must be 1000/2000 level courses in biology. These courses must be approved by the Director if not listed below. Students must receive a B or better in all courses. Students pick a research mentor by the beginning of their first semester in the program and do research for the duration of their time in the program. Students prepare a written thesis and present their work as a seminar for the final defense.

SUMMARY OF REQUIREMENTS:
- 8 structured upper level biology and engineering courses. Up to 3 may be independent study conducted under research advisor.
- At least 2 courses must be biology, 2 must be engineering
- Department Graduate Student Seminar courses do not count toward the degree
- Must receive a B or better in all 8 courses
- Choose a thesis committee, with your research advisor, which must be made up of BME faculty: one faculty from the School of Engineering, one from the Division of Biology and Medicine, and your advisor.
- Submit final written thesis 2 weeks before presentation to your Thesis Committee
- Present work as a seminar and pass final oral examination by thesis committee.

COURSES
Biology (At least 2 courses)

Fall
- BIOL 2050 Biology of the Eukaryotic Cell
- BIOL 1070 Biotechnology and Global Health
- BIOL 1290 Cancer Biology
- BIOL 2110 Drug and Gene Delivery
- BIOL 2860 Molecular Mechanisms of Disease
- BIOL 2320A Neurogenetics and Disease
- BIOL 1260 Physiological Pharmacology
- BIOL 1090 Polymer Science
- BIOL 1020 Synthetic Biological Systems
- BIOL 1140 Tissue Engineering

Spring
- BIOL 2310 Analysis of Development
- BIOL 2160 Analytical Methods in Biotechnology
- BIOL 1550 Biology of Emerging Microbial Diseases
- BIOL 1120 Biomaterials
- BIOL 1100 Cell Physiology and Biophysics
- BIOL 1180 Comparative Animal Physiology
- BIOL 1600 Development of Vaccines to Infectious Disease
- BIOL 2167 In Vitro Models for Disease
- BIOL 2145 Molecular Targets of Drug Discovery
- BIOL 2135 Pharmacokinetics and Drug Design
• BIOL 2010  Quantitative Approaches to Biology
• BIOL 1150  Stem Cell Engineering
• BIOL 1870  Techniques in Pathobiology
• BIOL 2540  Molecular Genetics

Engineering (At least two courses)
Fall
• ENGN 1490  Biomaterials
• ENGN 1210  Biomechanics
• ENGN 1930L  Biomedical Engineering Design, Research, and Modeling
• ENGN 1520  Cardiovascular Engineering
• ENGN 1930N  Intro to MRI and Neuroimaging
• ENGN 1230  Instrument Design
• ENGN 1510  Nanoeengineering and Nanomedicine
• ENGN 2530  Digital Signal Processing
• ENGN 2210  Continuum Mechanics
• ENGN 2340  Computational Methods in Structural Mechanics

Spring
• ENGN 2910M  Biosensors and Applied Microfluidics
• ENGN 2910S  Cancer Nanotechnology
• ENGN 2020  Mathematical Methods in Engineering and Physics
• ENGN 1220  Neuroengineering
• ENGN 1930B  Photonics and Biophotonics
• ENGN 2910G  Topics in Translational Research
• ENGN 1110  Transport and Biotransport
**Chemical and Biochemical Engineering (CBE)**
Graduate Representative: C. Franklin Goldsmith (franklin_goldsmith@brown.edu)

**Required Mathematics (select two):**
- **ENGN 2010** Mathematical Methods in Engineering and Physics I  **FALL**
- **ENGN 2020** Mathematical Methods in Engineering and Physics II  **SPRING**
- **APMA 2550** Numerical Solution of PDEs I  **FALL**
- **APMA 2560** Numerical Solution of PDEs II  **FALL**
- **APMA 2580B** Computational Fluid Dynamics  **SPRING**

**Required Engineering:**
- **ENGN 2730** Thermodynamics  **FALL**
- **ENGN 2750** Reaction Kinetics  **SPRING**
- **ENGN 2760** Heat and Mass Transfer  **SPRING**

**Recommended (choose at least one):**
- **ENGN 2810** Fluid Mechanics I  **FALL**
- **ENGN 2820** Fluid Mechanics II  **SPRING**
- **CHEM 2020** Statistical Mechanics  **SPRING**
- **ENGN 2912B** Scientific Programming in C++  **FALL**
- **ENGN 2770** Catalyst Design and Atomistic Reaction Engineering  **FALL**
- **ENGN 2910** Small Wonders  **SPRING**

**Selected Courses at the 1000 Level:**
- **ENGN 1120** Chemical and Biochemical Reactor Design  **FALL**
- **ENGN 1130** Phase and Chemical Equilibria  **FALL**
- **ENGN 1931P** Fuels, Energy, Power and the Environment  **FALL**
- **ENGN 1340** Water Supply and Wastewater Treatment  **SPRING**
- **ENGN 1110** Transport and Biotransport Processes  **SPRING**
- **ENGN 1140** Chemical Process Design  **SPRING**

**Notes**
- Not all courses are offered in each year — consult Banner for details.
- Each student should discuss his or her program with the graduate representative. Ultimately, the student is responsible for proposing a coherent set of courses that satisfies the School of Engineering ScM requirements.
- Graduate seminars offered by CBE faculty change year to year. They are strongly recommended even though not listed here.
Electrical Sciences and Computer Engineering (ESCE)
ScM Graduate Representative: Prof. Harvey Silverman (harvey_silverman@brown.edu)

Required math courses:

- Fall 2014 for ENGN 2010, or
  - APMA: 2190, 2410, 2550, 2570, 2630, 2670, 2810O, 2810Q
  - MATH: 2010, 2050, 2250, 2370, 2410, 2510, 2530

- Spring 2015 for ENGN 2020, or
  - APMA: 2120, 2200, 2560, 2610, (NOT 2420 or 2580A)
  - MATH: 2110, 2260, 2380, 2420, 2720

You can substitute at most one of the 2000-level math courses with one 1000-level math course after approval of the graduate representative.

Fall 2014 choices for 1000-Level APMA or MATH

- APMA: 1070, 1170, 1270, 1330, 1650*, 1690*, 1710, 1930M
- MATH: 1060, 1110, 1130, 1260*, 1270*, 1530, 1580, 1610

Spring 2015 choices for 1000-Level APMA or MATH

- APMA: 1080, 1180, 1200, 1360, 1660, 1720, 1740
- MATH: 1010, 1040, 1120, 1140, 1530, 1540, 1560, 1620

* A common one to take

Typical Courses for ESCE with Multimedia / Signal Processing Interest

Fall 2014

- ENGN 2530 Digital Signal Processing
- ENGN 1610 Image Understanding
- APMA 1690 Computational Probability and Statistics

Spring 2015

- ENGN 2540 Speech Processing
- ENGN 2020 Mathematical Methods in Engineering and Physics II
- ENGN 2520 Pattern Recognition and Machine Learning or
- ENGN 2560 Computer Vision

Fall 2015

- ENGN 2120B Scientific Programming in C++
- ENGN 1930N Introduction to MRI and Neuroimaging
Typical Courses for ESCE with Computer Engineering Interest

Fall 2014

ENGN 2911X  Reconfigurable Computing
ENGN 1600  Design and Implementation of Very Large-Scale Integrated Systems
APMA 1650  Statistical Inference I

Spring 2015

ENGN 2520  Pattern Recognition and Machine Learning
ENGN 1640  Design of Computing Systems
ENGN 2020  Mathematical Methods in Engineering and Physics II

Fall 2015

ENGN 2120B  Scientific Programming in C++
ENGN 2910  Advanced Computer Architecture

Typical Non-Thesis Program for ESCE with Electrophysics / Circuits Interest

Fall 2014

ENGN 2620  Quantum Electronics
ENGN 1590  Introduction to Semiconductors and Semiconductor Electronics
APMA 2010  Mathematical Methods in Engineering and Physics I

Spring 2015

ENGN 1931A  Photovoltaics Engineering
ENGN 2600  Electronic Processes in Semiconductors
ENGN 2020  Mathematical Methods in Engineering and Physics II

Fall 2015

ENGN 2980  Special Projects, Reading, Research and Design
ENGN 2912E  Low Power VLSI Design

Typical Non-Thesis Program for ESCE with Computer Vision Interest

Fall 2014

ENGN 1610  Image Understanding
ENGN 2912  Scientific Programming in C++
APMA 2010  Mathematical Methods in Engineering and Physics I

Spring 2015

ENGN 2560  Advanced Computer Vision or
ENGN 2520  Pattern Recognition
ENGN 2020  Mathematical Methods in Engineering and Physics II
Fall 2015
ENGN 2980 Special Projects, Reading, Research and Design
Elective course

Typical Non-Thesis Program for ESCE with Medical Imaging Interest

Fall 2014
ENGN2500 Medical Image Analysis I
ENGN 1610 Image Understanding
ENGN 2912 Scientific Programming in C++

Spring 2015
ENGN 250X Medical Imaging Analysis and Visualization (every other year) II
ENGN 2980 Special Projects, Reading, Research and Design
ENGN 2020 Mathematical Methods in Engineering and Physics II

Fall 2015
ENGN 2980 Special Projects, Reading, Research and Design
APMA 2010 Mathematical Methods in Engineering and Physics I

Notes

• Not all courses are offered in each year — consult Banner for details.

• Each student should discuss his or her course selections with the graduate representative. Ultimately, it is the student’s responsibility to propose a coherent set of courses that satisfies the ScM requirements.

• Other courses are acceptable with prior approval of the graduate representative.
Fluids and Thermal Sciences (FTS)
Graduate Representative: Prof. Kenny Breuer (kenneth_breuer@brown.edu)

**Required Mathematics:**
- ENGN 2010 Mathematical Methods in Engineering and Physics I FALL
- ENGN 2020 Mathematical Methods in Engineering and Physics II SPRING

*Other approved math courses (more challenging):*
- APMA 2550 Numerical Solution of PDEs I FALL
- APMA 2560 Numerical Solution of PDEs II FALL
- APMA 2580B Computational Fluid Dynamics SPRING

**Required Engineering:**
- ENGN 2810 Fluid Mechanics I FALL
- ENGN 2820 Fluid Mechanics II SPRING

**Recommended:**
- ENGN 2210 Continuum Mechanics FALL
- CHEM 2010 Thermodynamics FALL
- ENGN 2912B Scientific Programming in C++ FALL
- ENGN 2760 Heat and Mass Transfer SPRING

**Selected Courses at the 1000 Level:**
- ENGN 1700 Jet Engines and Aerospace Propulsion FALL
- ENGN 1930P Fuels Energy Power and the Environment FALL
- ENGN 1370 Advanced Engineering Mechanics SPRING
- ENGN 1710 Heat and Mass Transfer SPRING
  *(not acceptable if the graduate version ENGN 2760 is taken)*
- ENGN 1930U Renewable Energy Technologies SPRING
- ENGN 1760 Design of Space Systems SPRING
- ENGN 1720 Design of Engines and Turbines SPRING

**Notes**
- Not all courses are offered in each year — consult Banner for details.
- Each student should discuss his or her program with the graduate representative. Ultimately, the student is responsible for proposing a coherent set of courses that satisfies the School of Engineering ScM requirements.
- Graduate seminars offered by FTS faculty change year to year. They are strongly recommended even though not listed here.
# Materials Sciences

Graduate Representative: Prof. Axel van de Walle (avdw@brown.edu)

## Required Mathematics

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGN 2010</td>
<td>Mathematical Methods in Engineering and Physics I</td>
<td>FALL</td>
</tr>
<tr>
<td>ENGN 2020</td>
<td>Mathematical Methods in Engineering and Physics II</td>
<td>SPRING</td>
</tr>
</tbody>
</table>

## Required Engineering (choose 6)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGN 2400*</td>
<td>Electron Microscopy in Materials Science</td>
<td>SPRING</td>
</tr>
<tr>
<td>ENGN 2410</td>
<td>Thermodynamics of Materials</td>
<td>FALL</td>
</tr>
<tr>
<td>ENGN 2420*</td>
<td>Kinetic Processes and Mechanisms in Materials</td>
<td>SPRING</td>
</tr>
<tr>
<td>ENGN 2430*</td>
<td>Deformation Behavior of Materials</td>
<td>FALL</td>
</tr>
<tr>
<td>ENGN 2490A*</td>
<td>Crystal Structure and Crystallography</td>
<td>FALL</td>
</tr>
<tr>
<td>ENGN 2930*</td>
<td>Atomistic Modeling of Materials</td>
<td>SPRING</td>
</tr>
<tr>
<td>ENGN 2980</td>
<td>Special Projects, Reading, Research and Design</td>
<td>FALL/SPRING</td>
</tr>
</tbody>
</table>

## Alternative 1000-Level Engineering (replacing not more than 2 of the above 6)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGN 1410</td>
<td>Physical Chemistry of Solids</td>
<td>FALL</td>
</tr>
<tr>
<td>ENGN 1420</td>
<td>Kinetic Processes in Materials and Engineering</td>
<td>SPRING</td>
</tr>
<tr>
<td>ENGN 1440*</td>
<td>Mechanical Properties of Materials</td>
<td>FALL</td>
</tr>
<tr>
<td>ENGN 1450*</td>
<td>Properties and Processing of Electronic Materials</td>
<td>SPRING</td>
</tr>
<tr>
<td>ENGN 1470*</td>
<td>Structure and Properties of Nonmetallic Materials</td>
<td>SPRING</td>
</tr>
<tr>
<td>ENGN 1480*</td>
<td>Metallic Materials</td>
<td>SPRING</td>
</tr>
</tbody>
</table>

*These classes may be given every other year, depending on enrollment, and students should plan accordingly.

## Notes

- Not all courses are offered in each year — consult Banner for details.
- Each student should discuss his or her program with the graduate representative. Ultimately, the student is responsible for proposing a coherent set of courses that satisfies the School of Engineering ScM requirements. See [http://brown.edu/academics/engineering/graduate-study/scm-requirements](http://brown.edu/academics/engineering/graduate-study/scm-requirements).
- More challenging math courses may be substituted, with prior approval of the graduate representative.
- Other 2000- or 1000-level classes may be used in place of some of the above, with prior approval of the graduate representative. In particular, the Solid Mechanics program provides a good source of alternatives.
## Solid Mechanics (Solids)
Graduate Representative: Prof. David Hennan (david_hennan@brown.edu)

### Required Mathematics:
<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGN 2010</td>
<td>Mathematical Methods in Engineering and Physics I</td>
<td>FALL</td>
</tr>
<tr>
<td>ENGN 2020</td>
<td>Mathematical Methods in Engineering and Physics II</td>
<td>SPRING</td>
</tr>
</tbody>
</table>

For students seeking a more challenging math option:
<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>APMA 2550</td>
<td>Numerical Solution of PDEs I</td>
<td>FALL</td>
</tr>
<tr>
<td>APMA 2570</td>
<td>Numerical Solution of PDEs II</td>
<td>SPRING</td>
</tr>
<tr>
<td>APMA 2580</td>
<td>Numerical Solution of PDEs III</td>
<td>FALL</td>
</tr>
</tbody>
</table>

### Suggested Solid Mechanics Core:

**Basic Core:**
<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGN 1750</td>
<td>Advanced Solid Mechanics</td>
<td>FALL 2014</td>
</tr>
<tr>
<td>ENGN 2220</td>
<td>Mechanics of Solids</td>
<td>SPRING 2014</td>
</tr>
<tr>
<td>ENGN 2210</td>
<td>Continuum Mechanics</td>
<td>FALL 2015</td>
</tr>
</tbody>
</table>

**Advanced Core:**
<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGN 2210</td>
<td>Continuum Mechanics</td>
<td>FALL 2014</td>
</tr>
<tr>
<td>ENGN 2220</td>
<td>Mechanics of Solids</td>
<td>SPRING 2014</td>
</tr>
<tr>
<td>ENGN 2340</td>
<td>Computational Methods in Structural Mechanics</td>
<td>FALL 2015</td>
</tr>
</tbody>
</table>

### Other Suggested 2000-Level Courses:
*(Specific availability is given for courses not offered yearly)*
<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGN 2240</td>
<td>Linear Elasticity</td>
<td>FALL 2014</td>
</tr>
<tr>
<td>ENGN 2430</td>
<td>Deformation Behavior of Materials</td>
<td>FALL 2014</td>
</tr>
<tr>
<td>ENGN 2320</td>
<td>Experimental Mechanics</td>
<td>SPRING 2015</td>
</tr>
<tr>
<td>ENGN 2380</td>
<td>Fracture Mechanics</td>
<td>SPRING 2015</td>
</tr>
<tr>
<td>ENGN 2340</td>
<td>Computational Methods in Structural Mechanics</td>
<td>FALL 2015</td>
</tr>
<tr>
<td>ENGN 2490A</td>
<td>Crystal Structures and Crystallography</td>
<td>FALL 2015</td>
</tr>
<tr>
<td>ENGN 2920A</td>
<td>Complex Fluids: Particles and Interfaces</td>
<td>FALL 2015</td>
</tr>
<tr>
<td>ENGN 2912B</td>
<td>Scientific Programming in C++</td>
<td>FALL</td>
</tr>
</tbody>
</table>

### Selected Courses at the 1000 Level:
<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGN 1750</td>
<td>Advanced Solid Mechanics</td>
<td>FALL</td>
</tr>
</tbody>
</table>

*For students looking to reinforce their mechanics background*

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGN 1931D</td>
<td>Design of Mechanical Assemblies</td>
<td>FALL</td>
</tr>
<tr>
<td>ENGN 1440</td>
<td>Mechanical Properties of Materials</td>
<td>FALL 2014</td>
</tr>
<tr>
<td>ENGN 1470</td>
<td>Structure and Properties of Nonmetallic Materials</td>
<td>SPRING 2015</td>
</tr>
<tr>
<td>ENGN 1860</td>
<td>Advanced Fluid Mechanics</td>
<td>SPRING</td>
</tr>
</tbody>
</table>

### Notes
- Not all courses are offered in each year — consult Banner for details.
- Each student should discuss his or her program with the graduate representative. Ultimately, the student is responsible for proposing a coherent set of courses that satisfies the School of Engineering ScM requirements.
- Other courses may be acceptable with prior approval of the graduate representative.
### Sample ScM plans for Solid Mechanics

<table>
<thead>
<tr>
<th>SEMESTER</th>
<th>COURSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>FALL 2014</td>
<td>ENGN 2010, ENGN 1750, Elective</td>
</tr>
<tr>
<td>SPRING 2015</td>
<td>ENGN 2020, ENGN 2220, Elective</td>
</tr>
<tr>
<td>FALL 2015</td>
<td>ENGN 2210, Elective</td>
</tr>
</tbody>
</table>

Sample ScM program (more challenging track):

<table>
<thead>
<tr>
<th>SEMESTER</th>
<th>COURSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>FALL 2014</td>
<td>ENGN 2010, ENGN 2210, Elective</td>
</tr>
<tr>
<td>SPRING 2015</td>
<td>ENGN 2020, ENGN 2220, Elective</td>
</tr>
<tr>
<td>FALL 2015</td>
<td>ENGN 2340, Elective</td>
</tr>
</tbody>
</table>

Sample ScM program (thesis option):

<table>
<thead>
<tr>
<th>SEMESTER</th>
<th>COURSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>FALL 2014</td>
<td>ENGN 2010, ENGN 2210, Elective</td>
</tr>
<tr>
<td>SPRING 2015</td>
<td>ENGN 2020, ENGN 2220, ENGN 2980 (thesis)</td>
</tr>
<tr>
<td>FALL 2015</td>
<td>ENGN 2340, ENGN 2980 (thesis)</td>
</tr>
</tbody>
</table>