CC212: Reality, Science, and the Modern World

Course Description. “Reality” is the second-semester Core natural sciences course, with an emphasis on computational and mathematical reasoning. The goal of the course is to open our students to the world of 20th/21st century scientific questions. Studies include the paradigm-shifting scientific theories which forced the 20th century into a new understanding of our relation to the physical world, beginning with relativity and quantum theory, and exploring emergence, neuroscience and artificial intelligence.

Faculty:

<table>
<thead>
<tr>
<th>Faculty</th>
<th>E-mail</th>
<th>Office</th>
<th>Office Hours</th>
<th>Thursday Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binyomin Abrams</td>
<td><a href="mailto:abramsb@bu.edu">abramsb@bu.edu</a></td>
<td>SCI 270B</td>
<td>T 3:30-5:30pm</td>
<td>3:30pm in CAS 318</td>
</tr>
<tr>
<td>Emily Allen</td>
<td><a href="mailto:eallen2@bu.edu">eallen2@bu.edu</a></td>
<td>CAS 119</td>
<td>M/W 12-1pm</td>
<td>5pm in CAS 318</td>
</tr>
<tr>
<td>Paul Lipton</td>
<td><a href="mailto:palipton@bu.edu">palipton@bu.edu</a></td>
<td>BSC 114</td>
<td>M 3-5pm</td>
<td>5pm in CAS 318</td>
</tr>
<tr>
<td>Robin Stevens</td>
<td><a href="mailto:rjs01@bu.edu">rjs01@bu.edu</a></td>
<td>CAS 119</td>
<td>W 3-5pm</td>
<td>3:30pm in CAS 318</td>
</tr>
<tr>
<td>Wayne Snyder</td>
<td><a href="mailto:snyder@bu.edu">snyder@bu.edu</a></td>
<td>MCS 147</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Learning assistant office hours: Wednesdays 5-7 pm in CAS 119. Your LAs this semester are Femke Hermse (fhermse@bu.edu), Weiyi Hu (weiyihu3@bu.edu), and Pooja Patel (poojav@bu.edu)

Lectures: Mondays, Wednesdays, and Fridays from 10am – 11 am in KCB 107.

Website: A course website is maintained on which will be posted notes, handouts, and original articles of interest. You can access the site by logging-on with your BU username at www.learn.bu.edu.

Course communication: Periodic e-mails will be sent to the entire class using the BU-link (registrar’s online information system). Make sure that you check your BU e-mail address regularly so that you do not miss any important messages. Please use a valid BU email address for email communication regarding CC212 issues. Please direct your questions about the course to cc212-questions@bu.edu. Emails sent to this address will reach all faculty of the course. Please do not use hotmail, yahoo or any other email account, as the spam filters of your teaching staff may ignore messages originating from these accounts.

Textbook and other required course materials. In addition to the PDF documents that are posted on the course website, the following materials are required for each student in the course. All required materials are available in the BU Bookstore, or may be purchased from other vendors (use the ISBN numbers below to make sure you get the correct edition).

9. A Turning Technologies RF Clicker will be provided to you at the first lecture
10. Non-programmable scientific calculator capable of logarithms; we recommend http://goo.gl/uRZQ8K.
Learning objectives

Content-specific objectives:

- Understand current thinking regarding the concepts of matter, energy, their interactions, and their conservation
- Understand relativity (Newtonian, special) and how it is a practical necessity in 21st century life
- Develop a conceptual understanding of the structure and behavior of the atom, including the quantum mechanical nature of the electron cloud
- Understand the driving force behind spontaneous processes and how they are governed by the second law of thermodynamics.
- Learn and apply the basic definitions and relationships of the concepts “mind,” “brain,” “consciousness,” and “intelligence.”
- Study the basic structure and biology of the brain, focusing on the role of networks of neurons.
- Understand the concept of “emergent property” and its relationship to the notion of intelligence.
- Understand the nature and limitations of computation by an algorithmic process. Understand the claims pro and con regarding the thesis of “Strong AI.”

Broader Educational Objectives

- Learn how to assimilate data from representative examples and truly understanding how the behavior in these cases derives from the fundamental principles at work.
- Learn to evaluate hypotheses based on application of the underlying principles.
- Study the application and limitations of abstract models of complex phenomena.
- Utilize basic experimental techniques to probe and understand physical phenomena through in-class inquiry experiences and at-home activities.
- Learn to think and write clearly about technical and scientific ideas.
- Learn to think critically about the future (e.g., of machine intelligence) using thought experiments and hypothetical reasoning.
- Develop comfort and facility with quantitative reasoning skills and application to real-world problems.

Course format. CC212 consists of three hours of lectures per week and one hour of discussion. Your grade will be based on your performance and contributions in all aspects of the course. Attendance is mandatory at all lecture and discussion sections. Students missing more than two course meetings will receive a grade penalty. Important announcements will be made in lecture, discussion, or on the course Blackboard site; these include reading assignments, problems, and/or worksheets.

Important note about lecture preparation: it is imperative that you read the relevant readings and review the notes from the previous classes before coming to class. In lecture we will spend the majority of the time selectively explaining the most challenging parts of the material, working through activities to understand the concepts, and going beyond the level of the readings, rather than just reiterating the readings. Please feel encouraged to ask questions during the classes.

Course policies:

Electronic devices: laptops, tablets, and cell phones are not permitted in class. You will find that a laptop is not a good vehicle for note taking in this course, as it is impossible to recreate the diagrams and figures we
will be discussing in class. All you will need to take notes in class is a pen or pencil and a notebook or some paper. Make sure to bring your clicker to all course meetings (lecture and discussion).

Absences: attendance is mandatory at all lecture and discussion sections. Students missing more than two course meetings will receive a grade penalty. A missed exam will count as zero. Additionally, a component of your grade will be assigned to participation in both lecture and discussion.

Academic misconduct: All work and conduct regarding this class are governed by the Rules and Regulations as described in the Boston University Academic Conduct Code. All students are responsible for understanding and following this Code. Specifically, all work that you submit in this class must be your own work. While you are encouraged to work in groups on homework assignments and to discuss strategies and concepts, each student must submit papers that represent their own work and is written in their own words. Students suspected of committing academic misconduct will be reported to the Dean’s office. For more information on Boston University’s updated Academic Conduct Code, please see: http://goo.gl/oOVCY4.

Copyright Laws and Protection: “The syllabus, course descriptions, packets, and handouts created for this course, and all class lectures, are copyrighted by the instructors of CC212. Except with respect to enrolled students as set forth below, the materials and lectures may not be reproduced in any form or otherwise copied, displayed or distributed, nor should works derived from them be reproduced, copied, displayed or distributed without the written permission of the course instructor. Infringement of the copyright in these materials, including any sale or commercial use of notes, summaries, outlines or other reproductions of lectures, constitutes a violation of the copyright laws and is prohibited. Students enrolled in the course are allowed to share with other enrolled students course materials, notes, and other writings based on the course materials and lectures, but may not do so on a commercial basis or otherwise for payment of any kind. Please note in particular that selling or buying class notes, lecture notes or summaries, or similar materials both violates copyright and interferes with the academic mission of the College, and is therefore prohibited in this class and will be considered a violation of the student code of responsibility that is subject to academic sanctions.”

Assessment:

Your work in CC212 will be assessed from a combination of quizzes, exams, activities, short papers, a term paper, and in-class participation. There will be four midterm exam: three will be given in class during the semester and the fourth will be given during the final exam period. If the need arises, the dates of the exams may be changed without notice. In case of a serious medical or other emergency that prevents you from attending an exam, e-mail us before the exam so we can discuss the situation and decide how to remedy it. Examination absences that are not arranged with us in advance, or for which a satisfactory serious cause that cannot be adequately documented, will result in a zero grade for that exam. No exceptions.

NOTE: make-up exams are not allowed due to travel.

Students will be asked to write weekly micro-papers that relate to the material most-recently presented in the class, the readings that are assigned for class and discussion, and lead articles from the scientific literature. Details about each assignment will be given in class each week.

Course grading:

- Exams (4 exams x 10% each) 40%
- Papers (micro-papers/blog, final paper) 30%
- Quizzes and activities, participation 30%

During the term, you will receive numerical grades for individual exams, quizzes, papers, and activities; we do not assign letter grades to these individual assessments. Your overall course letter grade will be determined, in part, on your total score for the course. There are no fixed or pre-designated percentages of each
grade; course letter grades will be assigned based on our assessment of how an individual performed relative to our absolute standards. This means that your grade is uncoupled from the grades of your classmates. Please note that we do not offer or accept extra credit assignments to augment your scores.

**Tips for Success in CC212**

CC212 is a 4-credit course, which means 4 contact hours with instructors as well as 2-3 hours of independent work each week for each credit (8 – 12 hours of independent work per week). Depending on the week, we suggest that you break down these out-of-class hours in the following way:

- Assigned readings, activities, and problems: 4 – 6 hours
- Reviewing and *discussing* material from class: 2 – 3 hours
- Research, planning, and paper writing: 2 – 3 hours
- *Total out-of-class time* 8–12 hours

**Note:** “discussing” material from class means working in study groups and going over problems, exercises, and reading material. Success in learning science requires students to see the material from many directions and to be able to articulate it in their own words. Students trying to work alone in this course will be at a tremendous disadvantage. We *highly* recommend that all work (except taking assessments and the actual writing of individual papers) for this class be done *in groups*. Please do not hesitate to ask for assistance in setting up a regular study.

### CC212 Tentative Schedule of Topics – Spring 2016

<table>
<thead>
<tr>
<th>#</th>
<th>Week</th>
<th>Lecture topics (MWF)</th>
<th>Readings from</th>
<th>Other</th>
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</thead>
</table>
| 1 | Jan 18 (2 lect) | Introduction, course goals  
Scales and measurements  
Relativity: reference frames, postulates | Cox & Forshaw,  
Chapter 1–3  
Worksheet #1 | *No classes Monday*  
*Classes begin Jan 19 (T)*  
**MP**: Expectations |
| 2 | Jan 25 | Relativity of time, length  
Consequences of relativity | Cox & Forshaw,  
Chapters 2, 3, 4  
Rhodes  
Worksheet #2 | **MP**: Einstein and Newton  
- absolutes and relative |
| 3 | Feb 1 | Nuclei and nuclear reactions  
Spectroscopy and resonance  
IR spectroscopy | Worksheet #3  
Mahaffy ch. 3  
Lindley | **MP**: nuclear chemistry,  
the atom bomb, and  
practical applications of  
special relativity |
| 4 | Feb 8 | Greenhouse gases  
Quantum theory and uncertainty | Mahaffy ch. 4  
Lindley | **Exam #1 (W)**  
**MP**: misconception in "uncertainty" – what do we know? What don’t we
<table>
<thead>
<tr>
<th>Day</th>
<th>Lecture/Discussion Topic</th>
<th>Readings / Worksheets</th>
</tr>
</thead>
<tbody>
<tr>
<td>W 1/20</td>
<td>Introduction, time scales</td>
<td>PDFs #1, #2</td>
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<tr>
<td></td>
<td></td>
<td>Worksheet #1 (Math skills)</td>
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<tr>
<td>R 1/21</td>
<td>Discussion #1 – scales and sizes</td>
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<tr>
<td>Date</td>
<td>Topic</td>
<td>Reading</td>
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<tr>
<td>F 1/22</td>
<td>Reference frames, relativity</td>
<td>Cox and Forshaw ch. 1-3</td>
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<tr>
<td>M 1/25</td>
<td>Time dilation and length contraction</td>
<td>PDF #3, #4 (derivations)</td>
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<tr>
<td>W 1/27</td>
<td>Spacetime, $E = mc^2$</td>
<td>Cox and Forshaw ch. 4-5</td>
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<tr>
<td>R 1/28</td>
<td>Discussion #2 – special relativity</td>
<td></td>
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<tr>
<td>F 1/29</td>
<td>Finish spacetime Atoms and nuclei</td>
<td>Worksheet #2 (density, atoms) Rhodes pgs 23-31, 42-52, 135-141</td>
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<tr>
<td>M 2/1</td>
<td>Binding energy and mass defect Nuclear fission Moles</td>
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<tr>
<td>W 2/3</td>
<td>Finish moles (this took way too long) What is light Activity #1: Springs and weight</td>
<td>Worksheet #3 (waves) Mahaffy ch. 3?? (IR)</td>
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<tr>
<td>R 2/4</td>
<td>Nuclear binding and bombs...</td>
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<tr>
<td>F 2/5</td>
<td>Light/matter interactions IR spectroscopy</td>
<td></td>
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<tr>
<td>M 2/8</td>
<td>IR spectroscopy Greenhouse gases and temperature balance</td>
<td>Worksheet #4 (IR) Mahaffy ch. 4</td>
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<tr>
<td>W 2/10</td>
<td><strong>Exam #1 (dim analysis, relativity, nuclei, light, resonance)</strong></td>
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<tr>
<td>R 2/11</td>
<td>Discussion on IR/Greenhouse gases</td>
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<tr>
<td>F 2/12</td>
<td>Start Quantum H atom spectrum activity (#2)</td>
<td>Lindley Intro + ch.3-5</td>
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<tr>
<td>T 2/16</td>
<td>Energy of Abs/Emission, Planck's constant Rydberg's mathematical formulation</td>
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<tr>
<td>W 2/17</td>
<td>De Broglie takes Einstein more seriously than Einstein does Schrodinger takes de Broglie seriously (matter waves)</td>
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<tr>
<td>R 2/18</td>
<td>Models, Rydberg, and the absorption/emission of light</td>
<td></td>
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<tr>
<td>F 2/19</td>
<td>3D matter waves Spin</td>
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<tr>
<td>M 2/22</td>
<td>Photoionization and photoelectric effect</td>
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<tr>
<td>W 2/24</td>
<td>Particle in a box model</td>
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R 2/25  H atom, matter waves, and Einstein (include some P in Box calculations)
F 2/26  Particle/wave duality of electrons
M 2/29  Finish particle/wave duality of electrons
W 3/2   Bonding (not on exam)
R 3/3   Big vs Little; Classical vs. Quantum
F 3/4   Exam #2

Read Von Bayer over the break!!
Two weeks on second law (which is plenty).