

**Physics 102 – Visions of the Multiverse**  
**Spring term 2014, University of Rochester**  
*Information, Syllabus, and Schedule*

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This is an introductory course designed for students in the humanities and other non-scientific fields who are interested in learning about science, physics and concepts of a multiple universe reality. Topics include the nature of science, Newton's laws, relativity, light, quantum mechanics, the nature of particles and forces, and cosmology. In the course of surveying the modern scientific view of the universe, a number of serious concepts of a multi-universe reality will be examined, including the many-worlds view of quantum mechanics, inflationary and string-based cosmologies. There are no prerequisites, no background knowledge is required and the material will be presented with very little mathematics. Substantial use will be made of demonstrations. This course is intended to be equivalent to our Physics 100 course in terms of satisfying cluster requirements.

**Course instructor:**

Prof. Steven Manly e-mail: [steven.manly@rochester.edu](mailto:steven.manly@rochester.edu)

Phone: 275-8473

Office: B+L 203E

Office hours: **Monday 11 am-noon and Wednesday 9:00-10:00 am or by appointment.** With my travel and your variable needs/schedules, I find that fixed office hours are not terribly practical. If I am out of town or if the listed time slots do not work for you, speak to me or send e-mail and we will find a mutually suitable time to meet.

**Course web site:**

Extensive use will be made of the web for distributing course materials, making announcements, etc. The class URL is

[http://www.pas.rochester.edu/~manly/class/P102\\_2014S/](http://www.pas.rochester.edu/~manly/class/P102_2014S/).

If you have difficulty reaching this site (and you've verified it is not your problem), please contact me. I will also use of the Blackboard course management system. In particular I will use that system to email the class, report grades, and distribute material that should not be openly accessible on the web. It is essential that you let me know if you are not receiving emails sent to the class. I apologize for using two web venues; but there are technical reasons why this works best for me/us.

**Lectures:**

Hoyt Auditorium, Monday and Wednesday from 2-3:15 pm

**Recitations:**

Wednesday, 4:50-6:50 pm, MEL 206, led by

Ingrid Koch ([ikoch@u.rochester.edu](mailto:ikoch@u.rochester.edu))

Wednesday, 7:40-9:40 pm, DEWEY 4162, led by

Christina Loniewski ([cloniews@u.rochester.edu](mailto:cloniews@u.rochester.edu))

**Textbook and readings:**

- Art Hobson, Physics Concepts and Connections, 5th edition (2010), Pearson Prentice Hall.
- SM, Visions of the Multiverse, New Page Books (2010). Sorry if it is in bad taste to use my own book; but, the book and course were designed together and I think it will work well for you.
- Many other readings from various sources. These will be posted and made available to you on BlackBoard and the class website each week.

**Philosophy and goals:**

Physics 102 is meant to be fun and interesting. There is nothing as wacky as reality and it will be my pleasure to take you on a guided tour of some of the delightfully twisted parts of our universe. This is a conceptual course. The use of mathematics will be limited.

I have three pedagogical goals in this course. When it is over, I hope you have an appreciation of the nature of science, how it works and what are its strengths and shortcomings. Second, I would like to paint for you the modern scientific view of the universe. Finally, I want to explore with you numerous concepts of a multi-universe cosmic reality – mostly arising in modern physics, though we will discuss other ideas. It is my hope that this experience will help you appreciate the depth of the strangeness in our universe and the degree to which science (and physics in particular) shapes the life you live.

**Lectures:**

Unlike many science courses, there is no textbook that fully covers the material in this course. As such, it is important that you attend lectures and recitation and keep up with the readings.

**Recitations:**

Each week you will meet for up to two hours in what we'll call a "recitation" section with a teaching assistant with whom I work closely. During this time you will work through a series of questions and simple quantitative problems that I will pose to you as a group. The questions are designed to promote discussion and critical analysis of the readings. The problems are designed to elaborate on selected topics and (sometimes) break new ground meant to support the goals of the course.

Your attendance of, and participation in, the recitations a very significant part of your evaluation in this course. As such, I request that you use name cards in each recitation. Each week your TA will be asked to evaluate your participation in recitation. No grade gets entered ( i.e., it counts as a zero) if you do not attend a recitation for a given week. If you attend, but participate minimally and/or seem not to have done all the reading that might be part of what is discussed in the recitation, you receive a "1" for that week. If you come to

recitation and are reasonably prepared and participate in a reasonable way, you receive a “2”.

We will have roughly 12 recitations during the course of the semester, depending on how we are progressing in lecture and the readings and the need to maintain some coherence/synchronization within the course. That means each student can get as many as 24 recitation points during the term. I understand that illnesses and worthy distractions happen and that you will need to set priorities at times that may prevent you attending recitation once in a while. In recognition of this, the recitation scores will be calculated assuming a perfect score of 18. In other words, you can miss 3 recitations and receive a 100 percent score for this part of the course. Things will scale proportionally if, for some reason, we end up having 11 or 13 recitations instead of 12.

You can attend either recitation section each week. Just be sure the TA leading the section you attend knows who you are.

### **Weekly short essays and/or conceptual summaries:**

Each week you will be asked to write something (generally a paragraph to a half page in length) on a topic/question that we are discussing. In some cases I will be asking you to write a short essay on questions like

- “Does such a thing as scientific truth exist?”
- “How does human bias hinder/help scientific progress?”
- “Why does Nobel laureate George Smoot say that the cosmic microwave background is ‘like seeing the face of God’?”
- “How is the cosmic landscape in the multiverse concept coming out of string theory related to the religious idea of intelligent design?”

In other cases, I will ask you to write a conceptual summary of an important reading/topic, such as:

- “Why do scientists believe we live in an expanding universe?”
- “Why does the belief in cosmic inflation imply that one believes that we live in at least two different types of multiverses.”

You will turn these writings in (method to be determined) by a certain date/time. The writings will be collected and distributed back to the class anonymously. Each of you will then be asked to read and rank order four essays/summaries written by your classmates. The rank ordering will be on a scale of 1 to 4, with 4 being best (judging criteria to follow). Each student’s essay will be part of several classmate-ranked groupings. The class TA’s and I will also rank random groupings. Each student turns in their rankings by a particular date/time and I and the class TA’s will collate the information and report back to you your average ranking for that week along with several anonymous examples that illustrate what works well (or not) and why.

The criteria used for judging the writings (in order of importance) are as follows:

- The essay or summary must be in the student's own words except where appropriate quotes are used with attribution. (This class isn't about copying blog postings from the internet that seem to fit the question.)
- The essay/summary must show thoughtfulness and evidence of reading/research into the topic/question at hand.
- Essays should exhibit a logical flow/format. For example, it should begin with a statement of the problem or issue and perhaps a hypothesis that will be defended in the writing. The essay should have background discussion that demonstrates the student has read the material. The essay should provide one to several examples of supporting evidence and/or quotes from the reading/research supporting the hypothesis. Finally, the essay should contain a conclusion that is based on the evidence and summarizes the findings.
- Conceptual summaries will need to contain particular important points/facts. For example, a conceptual summary of why we believe in an expanding universe/big bang should refer to the evidence from the redshifting of spectral lines from distant objects, the agreement between observation and predictions for the primordial abundance of elements in intergalactic space, and the observation of the cosmic microwave background.
- Reasonable execution. This is not an English writing class, but it is fair to rank a jumble of poorly organized and poorly written thoughts below a reasonably well-written paragraph with a logical flow and appropriate points.

We will track the writings you turn in and the rankings received. We will also track your ranking of other essays/summaries. Both the writing and ranking are seen as components of the class that will contribute to the evaluation. As with the recitations, you will receive up to three passes on writing essays/summaries and three passes on ranking essays/summaries through the course of the term. In other words, the way the evaluation will be structured, missing up to three essays (or rankings) will not count against you. Even if you miss writing an essay/summary one week, you will still be given the option to rank that week.

### **Evaluation:**

Your grade in this class comes from participation in the recitations and the writing and ranking of short essays/summaries done each week. I do not plan to have exams in this course. (We will revisit that if this system of participation and writing/ranking points seems to be not working.) The evaluation scheme of writings, rankings and recitation participation is new for this course. As such, I can't give you an algorithmic view of how it will translate into letter grades until I see how things are going. I hope to provide some feedback on the writings as we go and the recitation participation scores will also be available as we go. This is not a weed-out class. If you do the reading and put effort and thought into the essays and recitations, you should do quite well. If you don't do the reading and

skip recitations or act like a wall-flower in recitation and put no thought into this class, expect a low grade.

### **Course Schedule:**

This course syllabus is tentative. I may adjust the speed or topics as the course evolves. Reading assignments will be provided as we proceed through the term.

**Wednesday, January 15, 2014** – course intro, intro to the multiverse, human bias

**Monday, January 19, 2014** – No lecture, MLK holiday

**Wednesday, January 22, 2014** – Online lecture, no meeting in Hoyt - human bias, the human experience, the nature of science

**Monday, January 27, 2014** – Nature of science, space, time, kinematic variables, Newton's Laws

**Wednesday, January 29, 2014** – Newton's laws, special relativity

**Monday, February 3, 2014** – Special relativity, forces and fields

**Wednesday, February 5, 2014** – Fields and waves

**Monday, February 10, 2014** – Electromagnetic waves

**Wednesday, February 12, 2014** – Electromagnetic waves and the beginning of quantum mechanics

**Monday, February 17, 2014** – Wave-particle duality

**Wednesday, February 19, 2014** – de Broglie, atomic spectra, Bohr model of the atom

**Monday, February 24, 2014** – Bohr model, quantum mechanics and atoms

**Wednesday, February 26, 2014** – quantum probabilities and quantum weirdness, many worlds multiverse

**Monday, March 3, 2014** – Quantum uncertainty

**Wednesday, March 5, 2014** – Nuclear physics

**Monday, March 10, 2014** – No lecture, spring break – woohoo!

**Wednesday, March 12, 2014** – No lecture, spring break

**Monday, March 17, 2014** – Nuclear physics, stars, particle physics

**Wednesday, March 19, 2014** – Particle physics

**Monday, March 24, 2014** – Man's place in the cosmos, general relativity

**Wednesday, March 26, 2014** – Big bang cosmology

**Monday, March 31, 2014** – Problems with big bang cosmology, inflation

**Wednesday, April 2, 2014** – Learning from the cosmic microwave background, inflation, dark matter, dark energy

**Monday, April 7, 2014** – Inflation and associated cosmological multiverses

**Wednesday, April 9, 2014** – Warped space and strings

**Monday, April 14, 2014** – String theory and the cosmic landscape

**Wednesday, April 16, 2014** – warped space and strings

**Monday, April 21, 2014** – strings and the cosmic landscape

**Wednesday, April 23, 2014** – ekpyrotic universe

**Monday, April 28, 2014** – anthropic principle, sims, religion

**Wednesday, April 30, 2014** – mathematical multiverse, multiverse taxonomy reprise

**Tuesday, May 3, 2011** – Final exam (if we have one), 4 pm, location TBA (*I'm not planning to have a final this term if the new evaluation scheme seems to work.*)