Instructor: Dr. Jatila van der Veen    Email: jatila@physics.ucsb.edu
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Class Hours: Fridays, from 2 PM to 4:55 PM
Office Hours: Mondays, 11 AM – 1 PM, or by appointment Tues - Thurs
Course website:

Assigned Texts

(1) Course Reader, available from AS Note takers window, adjacent to the Multicultural Center
(2) Fearful Symmetry, by A. Zee (2007 edition), available from the UCSB bookstore, or Amazon on line
Note: These are fairly small and light-weight, so please bring them with you to class each week so you can refer to them during the discussions.

General Expectations

There are two types of assignments: weekly reading reflections and art projects.
You are expected to do BOTH.

(1) Reading Reflections (RRs): DUE EACH WEEK. For each article or book chapter that you read, you are to write a Reading Reflection (RR), which you are to turn in, either in hard copy in class, or via email before class. I don’t want a summary of what the author wrote; rather, I am looking for your reaction to the work. In the list of reading assignments I have written an “RR prompt” for each reading to help you get started, but feel free to take off in whatever direction you are inspired to go.

(2) Arts-based assignments: In addition to the reading reflections, there will be 3 arts-based assignments plus a final physics-art project. These assignments are explained in detail below.

Grading Policy

CCS courses, even electives, have high expectations, and are “worth” 4 credit points. All CCS classes are pass/no pass, but 4 points is equivalent to an A, 3 points a B, etc, even though only “P” for pass will appear on your transcript. (If you are not in CCS and need a letter stating that you would have received an A, please contact me in the Spring Quarter and I will be happy to write one.)

late work policy: I don’t have one, and don’t believe in them. I expect you to participate in all classes, assignments, discussions, field trips, etc., as honestly and authentically as you can. On the other hand, everyone is human, and sometimes *stuff* happens. Talk to me if you have a problem with any assignment, need more time, or have a family emergency or illness that will interfere with your participation. Feel free to call my cell, listed above.
1. Visualization of Einstein’s Process of Physics, due: January 16th

Einstein writes quite descriptively, with language that is grounded in his personal style of visualization and imagery. In fact, he is quoted as having said that images played a much more important role in his understanding of physics than words or equations. His writing is a bit dense, so you may have to go over passages several times, but once you get the flow of his language some clear images will hopefully emerge in your mind.

I have two objectives for this assignment:
1. That by drawing what Einstein is describing you will gain a deeper insight into the concepts he is trying to put across, which are more like the way physics is really done than what you may have been taught in lower school;
2. That by drawing the way you visualize Einstein’s description, you will gain some insight into the way your mind works, and how your brain naturally processes information. It does not matter if you have no art training – just try to get down on paper some representation of what you see in your mind’s eye.

Drawing prompt: What is the process of doing science (physics), according to Einstein? How do you visualize this process as described by Einstein? Your drawing should be a visual essay of your response to this article, so that you can explain to a general audience the process of doing science according to Einstein. Your work will not be evaluated on its technical merit! Your work will be evaluated according to these criteria: 1. Did you represent the process of doing physics, as described by Einstein, in your own way? 2. Can you explain how your drawing relates to Einstein’s article?

Turn in: Your drawing, and a brief description of how the elements in your drawing illustrate Einstein’s description of the process of doing physics. Please be prepared to share and discuss your drawing in class on the assigned day.

I want to emphasize: It does not matter if you are trained in art or not! No one cares. The purpose of this assignment is to get in touch with the way you visualize and conceptualize stuff.

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2. Symmetry demonstration, due Feb. 6th:

Symmetry in physics is operationally defined: A system (or object) is said to possess a certain type of symmetry if the following is true: When you make a change in the system (translation, rotation, reflection, or combinations thereof), OR if you make the same type of change in YOUR viewpoint, the system remains unchanged (invariant). Objects (“things” and “creatures” in the macroscopic world, particles in the subatomic quantum world) and spaces (geometries) are characterized by the sets of transformations (symmetry operations) that leave them unchanged.

Artistic Prompt: What familiar things do you see, hear, or otherwise notice, in your environment or in your imagination, and what symmetries do they have? Think of: axes of rotation, reflection planes, self-similarity, wall paper symmetry, temporal symmetry (as in music) or spatio-temporal symmetries as in dance or any periodic motion (such as
Symmetry and Aesthetics in Contemporary Physics, 2015

Choose one manifestation of symmetry that is most interesting to you and create a representation that you will present in class. This does not have to be a drawing, but you are free to work in any medium you choose: drawing, painting, sculpture, music, dance, computer simulation, or something else.

**Turn in:**
1. Your symmetry demonstration, presented in class;
2. A one-page write up in which you discuss the symmetry group your demonstration represents, the symmetry operations apparent in it, and any other information that would be interesting for your audience to know, such as why you chose it, how you created it, why you chose a particular medium or materials, and any symbolic meanings that you have chosen which you would like to explain.

3. Artistic explorations of spacetime concepts, due February 20th:

We have discussed the symmetries underlying Special and General Relativity. Special Relativity is a theory of spacetime without gravity, and General Relativity is a theory of spacetime in which the curvature of spacetime due to the presence of mass and energy causes that which we call gravity.

**Artistic prompt:** Relativity theory calls upon us to imagine a four dimensional reality. How can we honestly do this? Choose a concept that you find most intriguing about relativity, such as: length contraction/time dilation as measured by observers in moving reference frames; lack of simultaneity for moving observers; deformation of space and time; time stretching in a gravitational field or accelerating rocket; or something else from the readings or class discussions. Choose a medium in which you wish to work – drawing, painting, computer graphics, music, dance, poetry, etc. , and create a representation of your chosen concept.

**Turn in:**
1. Your representation of relativity, in class;
2. A write up of your representation that includes: (a) an explanation of the concept and a description of how your representation shows it; (b) what you want your audience to take away from the experience; and (c) how your experience of creating this representation deepened your own understanding of the concept.

Final Project: Physics Work of Art: Due March 13th, the last class.

For the final project, you are to create a Physics Work of Art (or Work of Physics Art, however you choose to look at it), which must illustrate, demonstrate, or explore one or more of the concepts we studied during the quarter. You may use any medium you like, and you may start from one of your previous assignments and build on it, if you wish.
Prompt: Now that you have learned something about the way your mind works by doing the previous artistic assignments, I want you to create a work of art that teaches something to an audience or viewing public. You may use any of the three previous projects as a starting point, or create something completely new.

Your work, which you turn in, must include the following elements:

1. Define and describe in words the concept you wish to explore.
2. Describe the aspect you wish to illustrate, demonstrate, or otherwise explore.
3. Describe the goal you have for your audience—what do you want your audience to take away from their experience of your work? How will their understanding, outlook, or lives, be changed by their experience of your work?
4. Describe the medium you will work in, and why this medium is well suited to your goal.
5. Present your work in class and to the public.

The CCS Art Gallery will be open for you to mount your work during finals week, March 16th.

You will present your work privately to the class on the last class, March 13th. You should mount your work in the CCS gallery on Monday, March 16th, some time between 10 AM and 4 PM.

We will decide on a day for a public reception during finals week. During the reception you need to stand by your work for the first hour, and explain your piece to the public. After that you are free to mingle. I will provide food and drinks. PLEASE INVITE YOUR FRIENDS AND FAMILY!

We will leave the show up all during finals. Please come take your piece down before you leave for spring break.

As always, I am available to consult with you on any of the assignments, either during office hours or by appointment.

Above all, have fun with these projects!
Schedule of Topics & Readings for Winter Quarter, 2015
Symmetry and Aesthetics in Contemporary Physics

Topic for Jan. 9th: First Class – What is reality, and how do we know stuff? What is the nature of math and why does it seem to be so ingrained in Nature?

Topic for Jan. 16th: Beauty in Scientific Theories; the Nature of Reality; Relationship between perception and reality

Reading due Jan. 16th:


RR prompt #1, due Jan 16th: Einstein is responsible for profoundly changing the way we think about the physical universe. Although he received the Nobel Prize for his work on the photoelectric effect, he is best known for his theories of Special and General Relativity, and his (misquoted) equation “E = mc^2”. He was also a very visual thinker.

a) What points that Einstein makes strike you as most relevant to the way you think science is done today?
b) What points that Einstein makes stand out to you as most interesting or controversial? Please be prepared to discuss your views in class.

First drawing project also due Jan. 16th – drawing plus a brief written explanation of your drawing. See description of art projects.

Topic for Jan. 23rd: What considerations motivate the search for fundamental laws in Physics?

Readings due Jan. 23rd:


RR prompt #2, due Jan. 23rd: Reflecting on these two articles, I’d like you to address these points (and any others you wish):

1. Chandrasekhar discusses the sense of beauty and aesthetics in searching for fundamental laws of physics, and Hartle describes the search for regularities in describing the fundamental laws of physics. Do you see these two viewpoints as complimentary, intertwined, or opposing?
2. What points that each author makes resonate most with you? Are there any points with which you disagree?
Schedule of Topics & Readings for Winter Quarter, 2015
Symmetry and Aesthetics in Contemporary Physics

Topic for Jan. 30th: Introduction to Symmetry, Galois Theory, and Classifying *things* by their Group Interactions

Reading due Jan. 30th:
2) Chapter 1 (Symmetry) and Chapter 2 (eyE s’dniM eht ni yrtemmyS).

RR#3 prompt:
1) What did you learn from these two chapters about Symmetry that is new for you, that you find particularly interesting or curious, or that you want to learn more about?
2) What connections to the topics you are studying outside of this class came up for you as you read these chapters? Please be prepared to discuss your views in class.

Art project due this day: Symmetry demonstration, due January 30th:

Topic for Feb. 6th: Symmetry as it relates to Laws of Physics

Readings due Feb. 6th:
1. Fearful Symmetry by Tony Zee: Chapter 2 (Symmetry and Simplicity) (Chapter 1 is optional – a nice introduction, which more or less duplicates what you read in Livio last week, but Tony says it differently.)

RR prompt: Feynman and Zee offer you two different perspectives on explaining why Symmetry is the foundation of the Laws of Physics. What do you take away from each author? What questions do you have after reading each article? Do you get any ‘feeling’ for each author from his writing? As always, please be prepared to discuss your views in class.

Topic for Feb. 13th: Into the nuts and bolts of Space-time Symmetry and Special Relativity

Reading due Feb. 6th:
Fearful Symmetry, Chapters 3 (The Far Side of the Mirror) and 4 (Marriage of Time and Space)

RR prompt: What do you take away from these chapters about how Symmetry has propelled the search for deeper laws of physics? As always, please be prepared to discuss your views in class.

Topic for Feb. 20th: Symmetry and the Shape of Spacetime (Intro to General Relativity!)

Reading due Feb. 20th:
Schedule of Topics & Readings for Winter Quarter, 2015
Symmetry and Aesthetics in Contemporary Physics


RR prompt: Feynman explains how spacetime is curved by the presence of mass, and that a ball tossed in a parabola on Earth is traveling through a helluva lot of curvature in time, and that light loses energy when it climbs out of a gravitational well. Yikes! What strikes you from this chapter as intriguing, impossible to understand, unbelievable, and/or [add your own adjective]? Cite specific pages to back up your opinions. As always, please be prepared to discuss your views in class.

Artistic explorations of spacetime concepts, due February 20th

Topic for Feb. 27th: More about General Relativity and its Implications

Reading due Feb. 27th:
Fearful Symmetry: Read Chapters 5 (A Happy Thought) and 6 (Symmetry Dictates Design)

RR prompt: Comment about whatever strikes your fancy, but at the very least, please explain what is meant by general covariance in your own words in writing, and be prepared to discuss and defend this in class.

Topic for March 6th: Looking for clues in cosmology and further theoretical models

Readings due March 6th:

Reader:
7. Efstathiou, George (2010). Unraveling the Big Bang with the Planck Satellite, downloaded from the planck.cf.ac.uk/files/Efstathiou_launch.pdf


Last RR prompt: Reflect on these three articles.
As we have discussed in this course, the search for fundamental laws of physics is motivated by the sense of aesthetics and beauty expressed in the regularity of the laws of nature – at least, this is the sense of aesthetics that is pleasing to theoretical physicists. However, theories are nothing in physics if they cannot be supported by observational evidence.

For this final RR, I’d like you to reflect on how these three articles tie together the concepts we have been discussing throughout the course: Efstathiou’s article discusses experimental evidence for fundamental theories from the CMB - the most ancient light we can detect by the most sophisticated microwave satellite to date; Lisi’s article on theoretical reasons for “believing in”
the universe as a permutation of the highest possible symmetry group (E8); and Linde’s article on theoretical reasons to “believe in” the self-replicating multiverse.

1. How do these articles tie together and wrap up the ideas we discussed in this course?
2. What further questions are you left with?

Optional Reading:

10. Miller, Johana (2012). The Higgs particle, or something much like it, has been spotted. Physics Today, Sept. 2012

You can find Prof. Linde’s original article here: http://www.stanford.edu/~alinde/1032226.pdf where you can see his art work more clearly.

You can find Prof. Lisi’s TED talk, with his visualizations, here: http://www.ted.com/talks/garrett_lisi_on_his_theory_of_everything.html

NEXT WEEK March 13th: LAST CLASS – Your final Physics Works of Art are due.

☞ Final Project: Physics Work of Art: Due March 13th, the last class.
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<td>Fearful Symmetry: Chapter 2 (ch. 1 is optional) Reader: #5, by R. Feynman</td>
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<td>March 6</td>
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<td>March 13</td>
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**A* MEANS AN ART PROJECT IS DUE ON THAT DATE!**

Note: You will have the opportunity to mount your final physics works of art in the CCS Art Gallery during the day on MONDAY, March 16th. We will aim for having the public reception on Monday starting at 5 PM.