- Reminder: The final is from 9-12, Monday 5/4, in our classroom, SC B234 (**Not** the classroom we have had exams in.) Plan on the exam taking the entire 3 hours.
- *Note:* If you have accommodations for extended time, you may take the exam until 1:30. If you have an exam at 2pm, let me know and perhaps I can arrange for you to begin taking the exam before 9am.
- The final *will* be cumulative.
- The solutions to Problem Set 13 will soon be available (along with all the rest) in the sitting area outside my office. Solutions to this study guide should be available by Friday of this week.
- Cheat Sheet: You may use a 4×6 (or smaller) index card of notes. You can put anything you want to on it. I will still include the Vitruvian proportions and the Sacred Cut ratios on the exam, as they take up a lot of space. Everything else is up to you.
- Warning: As usual, this study guide is not intended to be a stand-alone study resource. In fact, this only covers the most recent material; use old study guides, past exams, and past assignments to study for the older material.
- Advice:
  - Spread studying out over the next several days
  - Look over what topics we covered, then review your notes and the reading. But as always, the single most effective way of studying is doing as many problems as possible. The problem sets and studyguides for Exams 1 through 3 are still on the course web page, if you'd like fresh copies.
  - Think about *why* each step is true. Ask yourself if each step makes sense.
  - How long should you study for this? I'd suggest an absolute minimum of 9 hours. If you've struggled with past exams, allow more time.
  - Remember: If you can not do the problems from start to finish without getting help from friend, tutor, solutions or me, you are not ready. This does not mean you should *memorize* how to do the problems – as you know from the midterm exams, the final will involve similar but not identical ideas. *Understand* how to do all of these problems as well as all your past homework problems; use that understanding to *do* all the problems with no help – *then* you should be prepared.
- Topics:
  - All the topics mentioned in the previous three study guides, still available on-line,

    Plus:

- How to convert a point in 2-space into a a complex number and vice-versa.
- What a seed is; using recursion/iteration to find the Mandelbrot sequence for a given seed (whether it's real or complex); graphing the orbit for a given seed, what it means for a seed to be *escaping*, *attracted*, and *periodic*; deciding whether a point belongs in the Mandelbrot set or not; and the distinction between coloring a point black or not-black.
- What a Linelander would see when a 2 dimensional object passes through its space, what a Flatlander would see when a 3 dimensional object passes through its space, and what we would see when a 4 dimensional object passes through our space. (I would only ask this for the appropriately dimensioned analog of the cube or sphere). By *see*, I really mean *experience through a combination of touch and sight, if given enough time to move around and feel as much as the dimensional restrictions allow.*
- Looking for patterns in the number of vertices, edges, faces, solids, etc in a point, line segment, square or triangle, cube or tetrahedron, and using the patterns to predict how many vertices, edges, faces, solids, 4-d regions and 5-d regions are in the hypercube, hyperhypercube, 6th dimensional cube, etc or hypertetrahedron, hyperhypertetrahedron, 6th dimensional tetrahedron, etc.
- Ways to visually represent the hypercube in 2 and 3 dimensions.
- The connection between the 4th dimension, non-Euclidean geometry, and early 20th century art – who were some of the artists that we know were influenced by these mathematical notions? (Juan Gris, Jean Metzinger, Albert Gleizes, Marcel DuChamp, and Max Weber are the ones whose work we saw in class. **Not** Picasso.)

- Problems:

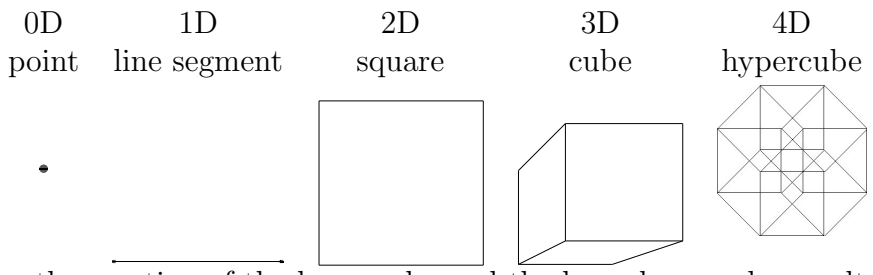
  The following problems are intended as a supplement to your review; they are not intended to replace reviewing the reading and class notes, or redoing homework problems.

  1. For each of the following seeds s,
     (i) Find the first 6 terms of the Mandelbrot sequence with seed s
     (ii) Sketch the orbit of seed s
     (ii) Is this Mandelbrot sequence *escaping, periodic,* or *attracted*? (For some, you may not be sure; pick which you think is the most likely.)
     (iii) Will the point in the plane identified with the seed be a black point, or a non-black point?
     (a) $s = (0.75, 0)$
     (b) $s = (-0.75, 0)$

(c) $s = (0, -2)$
(d) $s = (-0.1, -0.1)$

2. What would A. Square observe (assuming he has the leisure to walk around and perhaps even touch), if a cube passed through Flatland edge first?

3. Recall the creation of a line segment, square, cube, and hypercube:



Pondering the creation of the hypercube and the hyperhypercube resulted in the following table, up through dimension 5. Complete the final column for the sixth dimensional hyper-hyper-hypercube. You may use formulas we developed or the process of creating the hyperhyperhypercube, but not *just* patterns in the table. However you do it, give some brief explanation that involves the creation of the hyperhypercube.

Dimension Figure	0D point	1D line segment	2D square	3D cube	4D hypercube	5D hyper- hypercube	6D hyperhyper- hypercube
vertices v	1	2	4	8	16	32	
edges e	0	1	4	12	32	80	
faces f	0	0	1	6	24	80	
solids s	0	0	0	1	8	40	
4D regions t	0	0	0	0	1	10	
5D regions u	0	0	0	0	0	1	
6D regions w	0	0	0	0	0	0	

4. Use ideas and/or formulas developed in class to decide what the most likely intersection of a plane with a 3-space is in 4-space.