The plan outlines the math department’s goals and desired outcomes in utilizing the MITx platform both residentially and for globally accessible MOOC courses.

*Problems and engineering examples.* The math department has an internal log of problems and is currently working with applied mathematicians and engineering faculty to expand the problems to include more applications to engineering design and applied sciences. We plan to digitize these problems into a robust database of automatically gradable problems that assess math skills, conceptual understanding, and student ability to transfer tools to engineering and science applications. Such a database can help to ensure consistency in learning goals and student outcomes over time and with different instructors.

*Residential student experience.* By creating reading material and online problems, we hypothesize that students have an easier and more enjoyable time accessing the content, receive immediate feedback which may increase confidence and learning gains, and enables the classroom experience to be a more active and engaging experience. One long term project idea is to be able to incorporate design challenges involving engineering problems that would span 18.01r, 18.02r, and 18.03r. Because not all students take all three classes, having an accessible online format would be needed to allow students to recall, refresh, or learn what was done in previous classes.

*MOOCs.* Once resources are online, we expect to promote the MIT mission to create high quality courses for free that are globally accessible by running these courses as MOOCs. There is currently a two year plan to create 18.01 and 18.03 as MOOCs. If these courses go well, and the technology develops sufficiently, this would be followed by 18.02.

Some of these questions be answered through survey data. However, effective usage of clickstream data is currently beyond our scope as we are immersed in content creation. One possible avenue of exploration is to pursue an NSF grant fund a position for a researcher to devote time to the data. Another idea is to hire a post doc part time to be devoted to this analysis.

- 18.03r: Explore effective content organization through usage data and survey responses.
- 18.01r. Gather preliminary data on learning gains in 18.01 residentially to use in comparison to online course with Prof J Speck, who is teaching 18.01 in Fall 2014. We hypothesize that in a flipped classroom model, the gain may be larger; in an 18.01x course, we expect that the learning gains may be lower because of the limited feedback offered on the first run. But these gains provide a mark for improvement.
- 18.01x: Identify student misconceptions through self-explanations and crowd sourced hinting.

*Date:* June 26, 2014.
• 18.01r/x, 18.03r/x: Determine effects of increasing engineering examples in course on student perceptions of mathematics and its utility.

The math department currently has a variety of residential courses underway. We will describe the projects, the research questions, experiments and plans for each course. What has been done, and what we hope to accomplish, and experiments underway or anticipated.

18.01x/r.

• Team Prof. D Jerison, Prof. G Staffilani, J French, S Wang, J-M Claus

• Learning Sequences In 18.01, we are constructing learning sequences based on the OCW Scholar 18.01 course featuring Prof. D Jerison. Our philosophy is that one learns mathematics by doing mathematics, and thinking through mathematics. The learning sequences are designed to gain learner attention through an interesting context or engineering problem. We are exploiting the interactive environment to provoke conceptual thinking about new material, inducing students to recall what they have previously learned and connect it with what they are about to discover. After interactive problems, stimulus material is presented or a short recap explains a bigger picture through a short video, which segues to more practice problems, and concept questions aimed at common student misconceptions.

• Student Explanation Throughout problem sets and within the learning sequences, we are including problems that ask students to explain their reasoning or predict certain behavior. Some of these questions have multiple correct answers. We are not grading these self-explanations for two reasons. One is that the goal is to have students engage with the material so that they are able to be receptive to the answer, not to be correct a priori. The other is that we do not know how to grade them. This is a rich area for research into student misconceptions, and to allow data driven renovation of course content, and allow delivery of targeted feedback to students.

• Videos and Humanizing Mathematics We believe that human presence creates an emotional space that is beneficial for learning mathematics. However, cognitive learning theory tells us that a person can distract from the content. We have mitigated these concerns in our design of the learning sequences. Each motivational video or context will involve human beings—allowing personalities and humor of course creators to shine through. However, as new content is introduced within the learning sequence, we will use narrated Tablet videos (Kahn Academy Style) instead. We have chosen a color palette reminiscent of a blackboard with chalk because we find it soothing, friendly, and pleasantly reminiscent of our own experiences learning and teaching mathematics. This palette is also applied to the mathlets (see below). The links provided give examples of video we have created for this project: secant line definition, secant line slope and average rate of change, limit of secant lines, falling ball
example revisited, intro product rule, product rule preparation, product rule prep solution.

- **Mathlets** The math department has created a large library of java applets which are in the process of being fully translated into javascript. These applets, from here on called mathlets, explore mathematical concepts visually. So far 3 new mathlets are begin created this summer for 18.01, and more being translated. They key contribution is a graphing mathlet that will allow students to draw curves with specific features. This is a necessary step for a student to progress to expert behavior, which involves moving easily between formulaic, graphical, and physical representations of information.

- **Problems and Engineering Design** Students learn by doing. We are developing layers of practice problems and more applied problem sets that explore concepts important in science and engineering. In particular, we focus on using calculus to understand measurement error, linear and quadratic approximations, and to explore engineering contexts and design challenges. We are currently working with D Custer, S Socrates, P Hosoi, S Mahajan, and others to develop problems around zip lines, solid mechanics, and sports problems, and physics concepts respectively. We have a grant that is pending from the Alumni Fund to help support this work and develop new Mathlets to explore these engineering topics. We intend to explore crowd sourced feedback to support student learning.

- **Residential changes** Central to residential changes is the creation of the 18.01x MOOC. Starting Fall 2015, students will need a 5 on the AP AB or BC Calculus exam to be able to take 18.01 (currently they need only a 4). However, if they wish to pass out of 18.01, they still have an opportunity to pass the Advanced Standing Exam. Once 18.01x is available as a MOOC, we can point students to this course as a resource to prepare for the ASE.

  The residential version of 18.01r will use the content that we create. We intend to test these materials in Spring 2015 residually on a very small class (typically 4 or 5 students) in a flipped classroom model. We hope that this content will allow more time for students to work individually with a TA or Instructor to explore calculus as it is relevant to real world problems, and make greater learning gains.