Online Calculus
Associated Colleges of the Midwest

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The universe of online teaching and learning is big.
Technology is merely a tool.
An online course is, first and foremost, a course.
Calculus: A Modeling Approach
Associated Colleges of the Midwest

Beloit College
Carleton College
Coe College
Colorado College
Cornell College
Grinnell College
Knox College

Lake Forest College
Lawrence University
Luther College
Macalester College
Monmouth College
Ripon College
St. Olaf College

Schools with students in the course are colored blue.
Pilot: 2013

- **Small Participatory Online Course**
- 2 instructors
- 16 students from 8 colleges
- Geographically dispersed
- June 17 - August 9, 2013
- 8 - 10 hours/week student workload
- Applied Multivariable Calculus I @ Mac
Rerun: 2014

- Small Participatory Online Course
- 1 instructor
- 17 students from 6 colleges
- Geographically dispersed
- June 9 - August 2, 2014
- 8 - 10 hours/week student workload
- Applied Multivariable Calculus I @ Mac
Course Material

- Functions as models
- Fermi Estimation
- Dimensional Analysis
- Lin. alg. and model fitting
- Modeling and computation
- Multivar. diff. calculus
- Optimization
- Integration
- Differential Equations

No calculus prerequisite
Multivariable from day one
Transference is key
Weekly student learning tasks

- Video lectures (screencasts)
- Checkpoint quiz
- Online tutorial, office hours
- Homework assignment and unit quiz
- Online community forum (ongoing)
- Final exam (last week only)
For an average human in a resting (not exercising) state, the heart pumps about 5 liters (L) of blood per minute. In gallons per day, the pumping capacity (called the cardiac output) is closest to which value? Note that 2 gallon is about 3.8 liters.

(a) 20 gal/day
(b) 200 gal/day
(c) 2,000 gal/day
(d) 20,000 gal/day
Lectures
Lectures

Beyond unit conversion

Idea
Solve some problems just by combining/canceling units.

Example: How much energy is required to run a 100 W light bulb for one day? (1 W = 1 Joule/s = 1 J/s)

\[
\frac{100 \text{ J}}{\text{s}} \times \frac{60 \text{ s}}{1 \text{ min}} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \frac{24 \text{ hr}}{1 \text{ day}} \times 1 \text{ day} = 8.64 \times 10^6 \text{ J}
\]

Example: Assume sunlight deposits energy at the rate 250 W/m² on a 10 m² garden. How much energy is deposited over a month?

\[
\frac{250 \text{ J}}{\text{s} \text{ m}^2}
\]
Discussions

complex conjugate eigenvectors?
We spent a long time working on question 3 diagonalizing the matrix A. We tried to use eigenvectors that were not compl

Complete Matrix
When I read through the section for solving linear dynamical systems, I was confused about what it meant for a matrix to
• An instructor thinks this is a good note

error on notes
I believe that a negative appeared in the first entry of the S inverse matrix after the diagonalization section. Just f

Change of Variables
In the first example of Chad's notes, he does a change of variables to u and v. How does he do that, are they just arbit

Instr Office hour change for Wedne...
Hi folks, Because of MSCS capstone practice talks for seniors, I am shuffling tomorrow's office hours. I'll run from 2

The instructors' answer, where instructors collectively construct a single answer
Ok, sorry, I thought about your question a bit. I am not sure the question totally all real entries, if the eigenvalues are complex, then they must be complex co to a multiplicative constant. Now perhaps what you are asking is something like using the complex conjugate of v1 for the second eigenvector, we use the c the answer is that it should still work (I checked).

If you want to come in and talk about this and work out some details together,
Computer Lab

```r
> maunaloa <- read.csv("~/maunaloa.csv")
> View(maunaloa)
> plotPoints(CO2~Month, data=maunaloa)
> 
```
Tutorials and Office Hours

Equilibrium + Stability

\[ \frac{dQ}{dt} = 10 - 0.5Q \]

Equilibrium?

\[ \frac{dQ}{dt} = 0 \rightarrow 10 - 0.5Q = 0 \]

10 = 0.5Q

Q = 20
Student Results

- Student workload appropriate (3/5)
- Professors effective teachers (4.3/5)
- Tutorials useful (4.4/5)
- Students glad they enrolled (4/5)
Student Reflections

• I have never been super confident in math, but I understood WHY we were studying things in the course, which made it easier for me to master!

• I really liked how the course was set up in that we didn't have time limits when completing the exam and we were able to submit more than once. This allowed us to really learn the material if we got it wrong the first time.

• I think having the live Google+ hangouts was really beneficial and helped add a somewhat classroom-like feel to the course.

• I'm really glad Piazza was included! I had to use it for another class and detested it, but in this course it was extremely useful and a great way to practice my own knowledge as well as ask questions of my classmates.
Student Reflections

• Most online course stories I hear that there's no interaction or sense of community with the professors and students. However, this online course was quite the opposite so... **good job for making this online course above the rest, especially when it comes to interaction and community.**

• This truly was a great class, and **by far the best experience I have had with online learning thus far.** I would love to see this course continue. Thank you for the focus on LEARNING materials--I have never been confident in math, and I feel like the way in which the course was structured made me more able to engage with the material and master concepts. I am very pleased.
Challenges

• Time/expertise for course development
• Heterogeneity in student preparedness
• Weekly tutorial scheduling
• Instructor time for question response
• Staff time for technical support
• Tension between flexibility and community
• Energy for student engagement
**The Flipped Classroom**

**IN CLASS**
- Students apply key concepts with feedback

**OUT OF CLASS**
- Students prepare to participate in class activities
- Students check understanding, extend learning

**BEFORE**

**AFTER**
Applied Multivariable Calculus I: Typical Day

- Review concepts via computer demo (10 min)
- Q&A, discussion (15 min.)
- Specialized learning activity (40 min.)
- Homework (25 min.)
Activity: G.I. Taylor and the atomic bomb
Successful learning environments

Community Centered

Learner Centered

Knowledge Centered

Assessment Centered