Today

- Final Exam
  - 40 multiple choice questions
  - The questions will be very close to midterm exam questions
  - You can bring 3 sheets of paper
  - Use the midterm study guides
- Updated grades should be available by tomorrow evening
- Today: The Elegant Universe

Advice for the Exam

- Rates of change problems are important (Be able to find slopes and recognize where the slope is largest, zero, etc.)
- Know how to calculate how many electrons make up a certain charge
- Review Feynman Diagrams

The Elegant Universe

- Can we imagine that we can describe all of nature with one equation? F=ma
- Brian Greene wrote a book with the title and PBS made a video based on it. The book was a New York Times Best Seller for many weeks.
- The book describes the history of “unification” and String Theory
- Today we will watch some clips from the PBS video and discuss them. It will serve as a good review of the term.

Clips to Watch

- Episode 1 Chapter 1
- Episode 1 Chapter 3
- Episode 2 Chapter 1
- Episode 2 Chapter 7
- Episode 3 Chapter 4
- Episode 3 Chapter 5
My summary of the term

• What is time? Time is a dimension in our 4 (or maybe 11) dimensional universe. We can’t move backward in time because that would violate the 2nd Law of Thermodynamics.
• Rates of change rule! Position, Velocity, Acceleration, Force, Force Fields
• Quantities have units, amounts and sometimes directions (remember vectors?)

Forces

• We know of 4 in nature: gravity, electromagnetic, weak, and strong
• Are there more? We don’t know, but have not found any more.
• The modern view of force is in terms of field theory
• Feynman Diagrams

Particles and Quantum Numbers

• Quarks and Leptons come in three families
• Each force has a particle (s) that transmits it
• Charge is a fundamental property of nature
• Mass is the result of interaction with the Higgs particle (we think)
• E=mc²

Other things

• What is temperature? A measure of the average random kinetic energy
• What is entropy? The number of ways to order a system
• Scientific method: find models that work better by induction and deduction
In summary

• The Universe is an amazing place. 200 billion galaxies each with about 200 billion stars.
• Just this weak an Earth like planet was discovered about 200 ly from Earth. It has an orbit that would allow it to have liquid water.
• We are composed of stuff that makes up 4% of the Universe. We don’t know what the dark energy or dark matter are.
• We need to keep asking the why question.