Science, then, and now...

At the beginning, there were thoughts, and observation....

Science, then, and now...

- For a long time, people thought that it would be enough to reason about the existing knowledge to explore everything there is to know.
- One single person could possess all knowledge in her cultural context. (Encyclopedia of Diderot and D'Alembert)
- Reasoning, and mostly passive observation were the main techniques in scientific research.
Science, then, and now...

Theory → Experiments

Science, then, and now...

- Today's experiment yields massive amounts of data
- From hypothesis-driven to exploratory data analysis:
  - data are used to formulate new hypotheses
  - computers help formulate hypotheses
- No single person, no group has an overview of what is known

Science, then, and now...

Theory → Experiments → Data
Science, then, and now...

- Computer simulations developed hand-in-hand with the rapid growth of computers.
- A computer simulation is a computer program that attempts to simulate an abstract model of a particular system.
- Computer simulations complement theory and experiments, and often integrate them.
- They are becoming widespread in: Computational Physics, Chemistry, Mechanics, Materials, ..., Biology.

Mathematical Modeling

- Is often used in place of experiments when they are too large, too expensive, too dangerous, or too time consuming.
- Can be useful in “what if” studies; e.g. to investigate the use of pathogens (viruses, bacteria) to control an insect population.
- Is a modern tool for scientific investigation.
Define real world problem:
- Perform background research
- Perform experiments, if appropriate

Task: Understand current activity and predict future behavior

1) Simplification: define model
- Identify and select factors to describe important aspects of the Real World Problem;
- Determine those factors that can be neglected.
2) Represent: mathematical model

- Express the simplified model in mathematical terms
- The success of a mathematical model depends on how easy it is to use and how accurately it predicts.

3) Translate: computational model

- Change Mathematical Model into a form suitable for computational solution
- Choice of the numerical method
- Choice of the algorithm
- Choice of the software (Matlab)

4) Simulate: Results

- Run Computational Model to obtain Results; draw Conclusions.
- Graphs, charts, and other visualization tools are useful in summarizing results and drawing conclusions.
Mathematical Modeling

5) Interpret

- Compare conclusions with behavior of the real world problem
- If disagreement, modify Simplified Model and/or Mathematical model

Syllabus

- Introduction to Matlab
- The tools of the trade
- Data analysis
- Data modeling
- Clustering
- Fourier analysis
- Simulations (Monte Carlo)

References

(http://www.mathworks.com/moler)