# Course Outline

The outline below is arranged by week, with sub-topics suitable for lectures listed as well. I am assuming that the course must be taught in three one-hour lectures each week, but the outline, shown here by week, also allows for two 1.5-hour sessions if that fits a better schedule.

| Week | Topics | Example(s) from the Week's Topic | Concepts from Example Shown |
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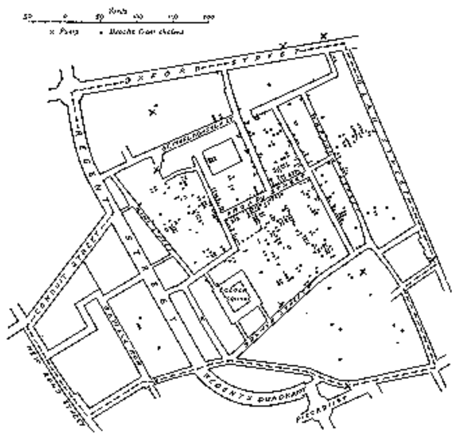
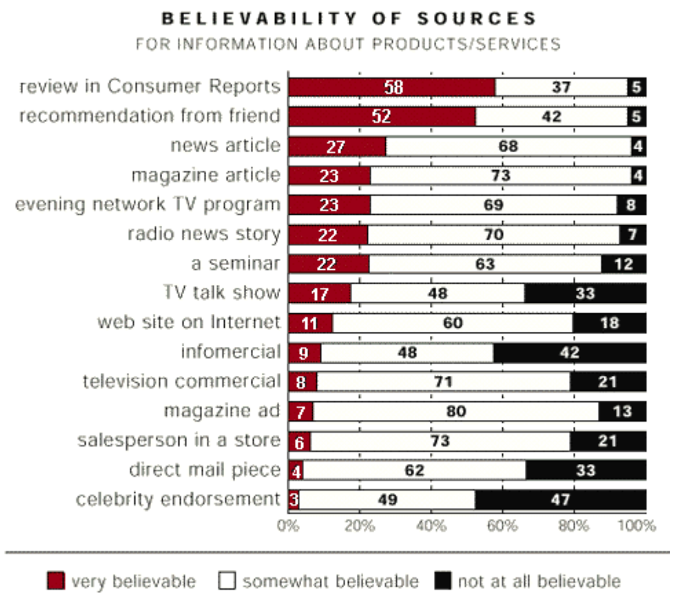
| 1 | *The History of Data Display*<br><br>*Basic Types of Data Display (e.g. Maps, charts, scatterplots, histograms, etc.)* | <br>*Thematic Mapping:* Dr. John Snow used the map shown here to isolate a contaminated well near a spatial concentration of deaths as a source of Cholera in the 1854 London Cholera epidemic. (This example is presented in detail in Tufte's textbooklet, required for purchase by the students.) | **Dimensionality:** Maps are two-dimensional in a literal way, while graphs can be two-dimensional in a more abstract way. (I will explain how the literal two-dimensional information in the map can be translated into other two-dimensional plots (e.g. death density vs. distance from pump, plotted for each pump).)<br><br>**Causality, significance**: How "certain" can we be that the contaminated pump caused the cholera outbreak? (We will dicuss various measures of "how bad" this pump was compared to others.) |
| 2 | *Types of Data Absolute Information Relative Information* | Is a mountain whose peak is listed at 8000 feet "twice" as high as one listed at 4000 feet, or should we measure from the center of the Earth? Is it "twice" as warm in Summer as in Winter because the Farenheit temperature is "twice" as high? What displays best address the answers to these questions? | **Scaling**: What quantities can or should have an absolute versus a relative scale?<br><br>**Credibility:** How can quantitative information be used to mislead? What is the source of the information presented? |

**3** *Tables vs. Graphs Histograms and "Frequency Distributions" Counting, Rating, and Ranking*




What kind of quantitative information belongs in a table, as opposed to a graph? How does one incorporate graphics into a table, and when does that add value?

What kind of information can be most deceptive? For example, do newer movies "break the opening-weekend record" because they are better, or because it becomes more and more expensive to see movies as time goes on? Should a film's popularity be measured in dollars or moviegoers?

**Pattern Recognition:** Tables, and simple graphs, often offer the human brain the most-easily digestible form of quantitative information. Up to what point (how much information), and why?

**Rank Ordering:** Some forms of data display focus one's attention on rank ordering (e.g. example at left). How else is rank ordering used? (e.g. mean vs. median)

**Small Multiples:** Sometimes patterns be used more effectively than numbers or words in a table.

**Credibilty:** What factors must one consider in evaluating a display?

**Bias and Selection Effects:** What data were selected for plotting, and how?

**Scaling:** Are the units offered the only relevant ones?

**4** *Graphs I: Scatterplots Function Plots*

The entire graphing section of the course will use examples from many sub-disciplines, including astronomy, biology, finance, geology, medicine, meteorology and political science. During Graphs I, we will focus on x-y plots, both discrete (scatterplots) and continuous (function plots).

In this first week, special emphasis will be placed on graphs being optimized to reveal information about a particular idea. Examples will include graphs with and without "predictive" power, and we will discuss how that power arises.

**Discrete and Continuous Variables:** What kinds of measurements are inherently one or the other? (e.g. political science vs. physical science data)

**Extrapolation:** What "model" is best used for various kinds of data? (including discussion of (schematic)

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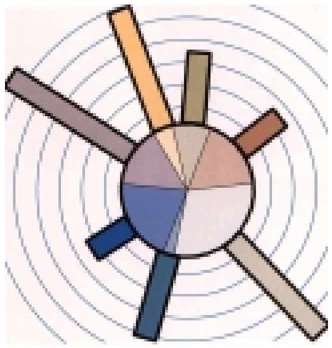
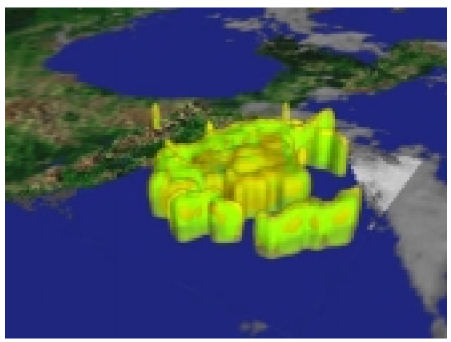
| | | | | linear regression)<br><br>**Error bars:** What is the meaning of a "1-sigma" error bar? |
| 5 | *Graphs II: Pie Charts Polar Plots Mid Term at End of this Week* |  | How can two dimensions be used to make displays other than scatter or function plots, and when are these appropriate? | **Coordinate Systems:** Bar, scatter, and many function plots usually use an x-y (Cartesian) coordinate system, when are others (e.g. radial) better?<br><br>**Proportionality and Fractions:** Pie charts are best used to illustrate this concept, and can be expanded to show more than just fractions (see illustration at left). |
| 6 | *Graphs III: Beyond Two Dimensions* |  | The human brain does best with two-dimensional displays, can fathom three dimensions, and fails almost completely beyond that. Nonetheless, space is inherently three-dimensional, and there is frequent need to display the distribution of some quantity over space. | **Dimensionality:** What number of dimensions is needed to describe a given situation? How are those dimensions best displayed?<br><br>**Projections:** How have the limitations of human brains been overcome? (Mercator projections and elementary trigonometry will be discussed.) |

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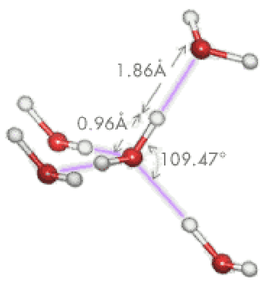
| 7 | *Maps Mathematical Illustrations* |  | Topology and Multiple Dimensions:<br>Geometric Calculations: |
| 8 | *Visual Statistics Potential Hellman (economics) or Epidemiologist Guest Lecture* | Case studies (likely from astronomy, economics and/or epidemiology) will be presented where several of the graphing and analysis methods studied thus far in the course can be applied. (The sample Project Set in this proposal would be distributed at this time.) | **Statistical Concepts** Illuminated: Mean, Mode, Median, Standard Deviation, Full/Half-Width Half-Maximum, Non-Gaussianity, Bias, Sample Selection. |
| 9 | *Potential Tufte Guest Lecture Subject-Specific Unusual Displays* |   Chemistry and biology present especially difficult challenges to those wishing to visualize their internal workings. We will focus on the simplest examples of chemical and biological displays, in part as an introduction to the discussion of the Human Genome project, the following week. | **Illustration of Geometric Relationships**<br>**Rules:** We will consider "rules" as a mathematical (logical) construct, and see, for example, how they effect genetic outcomes.<br>. |
| 10 | *Computers & the Web I Potential Krug Guest Lecture* | We will focus first on specific modern problems that *rely* on innovative displays of quantiative information for insight. Next, we will move on to the World Wide Web. In the Web discussion, we will focus on how to *extract* quantitative, meaningful information from the web, and on how best to offer (and display) such information. | **Economy in Information Display**<br>**Data Mining:** This section of the course will offer examples from the Human Genome project and/or the National Virtual Observatory, both of which fact enormous challenges |

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| | | | in extracting meaningful science from mountains of data. |
| **11** | *Computers & the Web II "How'd they do that?"* | Identifying some whiz-bang sites on the web, such as http://www.udel.edu/fth/java/MoleculeViewer/, that lets its user rotate molecules in three dimensions, we will discuss the underlying math necessary to make such displays. | **Applied Geometry and Trigonometry**: simple examples showing the connection to three-dimensional graphics |
| **12** | *Live Presentations* |  Whether we like it or not, PowerPoint has become an essential tool in practically every field.  In this section of the course we will discuss how to *avoid* over-using PowerPoint, when possible, by focusing on content rather than presentation. (I will also point out the best features of PowerPoint for displaying quantitative information.) | **Quantitative Information is About Numbers, not Words:** but, sometimes the best quantitative information displays *allow* us to put these mathematical principles into words. |
| **12.5** | *Course Conclusion* | Overview.  When to pictures describe words, when pictures describe numbers, when numbers describe words, and how to use pictures to bring numbers and words closer together. | |